EFFECTIVENESS OF CLOSED REAMING ANTIGRADE INTERLOCKING NAIL IN HUMERAL DIAPHYSEAL FRACTURES IN ADULTS

Dissertation submitted to

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MASTER OF SURGERY

IN

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CERTIFICATE

This is to certify that this dissertation titled **"EFFECTIVENESS OF CLOSED REAMING ANTIGRADE INTERLOCKING NAIL IN HUMERAL DIAPHYSEAL FRACTURES IN ADULTS"** is the bonafide original work of Dr.Lakshmikanth,M.E in the partial fulfilment of the requirements for M.S Orthopaedics Examination of the TamilNadu Dr.M.G.R Medical University to be held in APRIL 2015.The period of study is from July 2012 to June 2014.

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DECLARATION

I, Dr.Lakshmikanth,M.E, solemnly declare that this dissertation "**EFFECTIVENESS OF CLOSED REAMING ANTIGRADE INTERLOCKING NAIL IN HUMERAL DIAPHYSEAL FRACTURES IN ADULTS"** is a bonafide work done by me at Government Thanjavur Medical College and Hospital between 2012 – 2014, under the guidance and supervision of Prof.Dr.S.Kumaravel,M.S.Orth,D.Orth,Ph.D., Department of Orthopaedic Surgery.

This dissertation is submitted to the TamilNadu Dr.M.G.R Medical University towards partial fulfilment of regulation for the award of M.S Degree (Branch II) on Orthopaedic Surgery.

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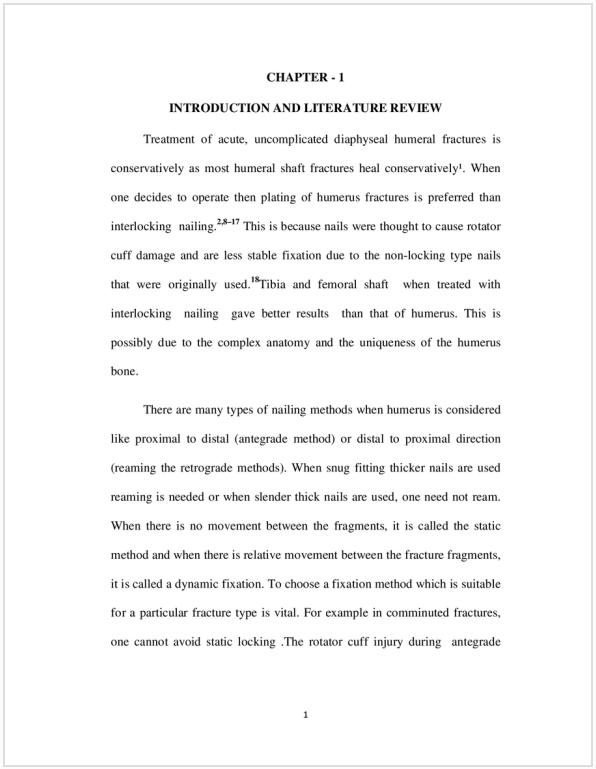

CHAPTER - 1

INTRODUCTION AND LITERATURE REVIEW

Treatment of acute, uncomplicated diaphyseal humeral fractures is conservatively as most humeral shaft fractures heal conservatively[1]. When one decides to operate then plating of humerus fractures is preferred than interlocking nailing.[2,8–17] This is because nails were thought to cause rotator cuff damage and are less stable fixation due to the non-locking type nails that were originally used.[18]Tibia and femoral shaft when treated with interlocking nailing gave better results than that of humerus. This is possibly due to the complex anatomy and the uniqueness of the humerus bone.

There are many types of nailing methods when humerus is considered like proximal to distal (antegrade method) or distal to proximal direction (reaming the retrograde methods). When snug fitting thicker nails are used reaming is needed or when slender thick nails are used, one need not ream. When there is no movement between the fragments, it is called the static method and when there is relative movement between the fracture fragments, it is called a dynamic fixation. To choose a fixation method which is suitable for a particular fracture type is vital. For example in comminuted fractures, one cannot avoid static locking .The rotator cuff injury during antegrade

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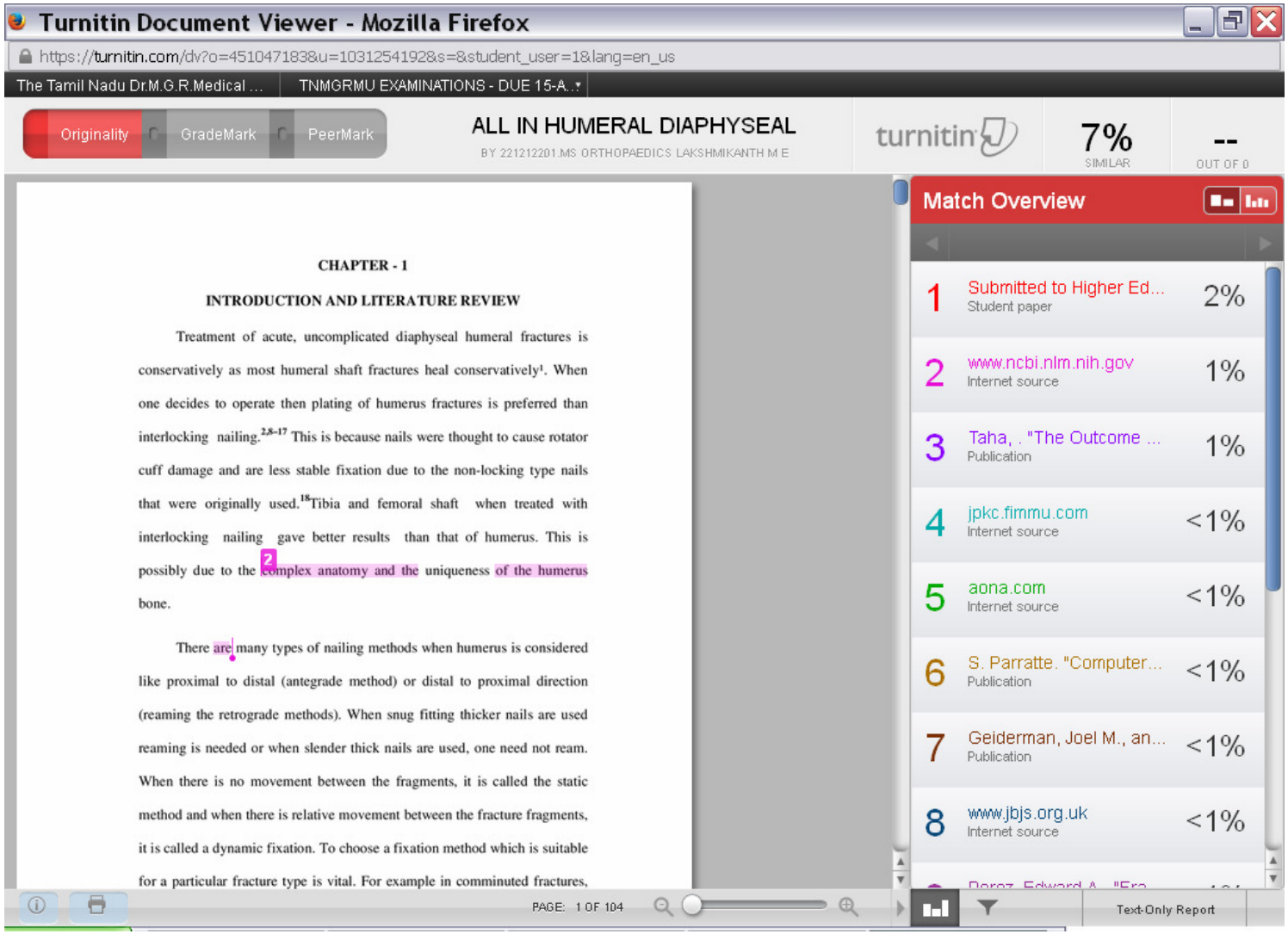
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I wish to thank God Almighty for giving me the health and strength to complete this study.

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TABLE OF CONTENTS

ABSTRACT

31 cases of adult humeral shaft fractures from vehicle accident were taken up for surgery within a average period of seven days .A closed humeral interlocking nailing was done in all these cases, under image intensification control, with acceptable reduction .Except for one case which has less than full shoulder abduction due to poor adherence to follow up, all other case has no any specific complication. 90.3 % of case had excellent goodresults. This study found that in adult humerus shaft fracture closed reduction and interlocking nail, result in quick rehabilitation and acceptable results.

Keywords :

Closed reduction, interlocking nail, humerus shaft fractures, minimally invasive surgery.

1.INTRODUCTION AND LITERATURE REVIEW

Treatment of acute, uncomplicated diaphyseal humeral fractures is conservatively as most humeral shaft fractures heal conservatively[1]. When one decides to operate then plating of humerus fractures is preferred than interlocking nailing.[2,8–17] This is because nails were thought to cause rotator cuff damage and are less stable fixation due to the non-locking type nails that were originally used.[18]Tibia and femoral shaft when treated with interlocking nailing gave better results than that of humerus. This is possibly due to the complex anatomy and the uniqueness of the humerus bone.

There are many types of nailing methods when humerus is considered like proximal to distal (antegrade method) or distal to proximal direction (reaming the retrograde methods). When snug fitting thicker nails are used reaming is needed or when slender thick nails are used, one need not ream. When there is no movement between the fragments, it is called the static method and when there is relative movement between the fracture fragments, it is called a dynamic fixation. To choose a fixation method which is suitable for a particular fracture type is vital. For example in comminuted fractures, one cannot avoid static locking .The rotator cuff injury during antegrade

humeral nailing is attributed to the poor results in shoulder .[5,14-17]There are new methods that avoid the rotator cuff with modified nails.[19,20,21]

Even patients with humeral shaft fractures treated by bracing or plating which did not interfere with shoulder structures had shoulder problems, possibly due to prolonged immobilization.[5,21-25]Even when retrograde nailing is done in fresh cases, there was an unexplained shoulder stiffness reported.[25] Thus shoulder impairment can occur without direct surgical intervention to the shoulder joint following fracture of shaft of humerus . Thus the nail entry into the proximal humerus is not the only way the rotator cuff injury or shoulder problem is caused. Recently significant number of humeral shaft fractures had antegrade un-reamed intramedullary nailing, had good results due to protecting the rotator cuff and repairing it after the nail insertion. [25] Apart from injury during the nail insertion as considered, there is a lot of possibility of injury to not only biceps tendon but also the axillary nerve while proximal locking bolts are applied in antegrade interlocking humerus nailing.[26-33]Such a complication will be less if direction of the proximal locking bolts shall be in front to back direction. This sort of interlocking avoiding injury to the soft tissues mentioned is possible in retrograde nailing of humeral fractures.[34] There is an anteroposterior technique described [35],[36,37]

In regular distal interlocking of an antegrade humeral nail is tough and time consuming as a correct view of the humerus cannot be easily obtained with the image intensifier. This is mainly because of small locking holes distally. This coupled with the fact that slippery status of the anterior aspect of shaft of humerus need extra care should be exercised while drilling for the distal locking screw as there are vital neurovascular structures. To avoid this complication or difficulty, a distal locking design in lateral to medial direction is proposed but it can cause injury to the radial nerve. C- arm vision is also easy with patients flexed elbow kept over the image intensifier. This is at the cost of loss of reduction of fracture.[36,37]

A single locking screw in the distal hole is sufficient for humeral shaft fracture stability to allow early joint mobilization including those movements for day to day activities. Open, see and drill technique is the gold standard as there is utter inconsistency with the zig available for distal locking.[36,38,39]Since there is a chance of injury to the radial nerve in lateral to medial direction injury , [26,28,36,37,40,41,42] With a small incision and dissection off the lateral condyle to supracondylar area the distal locking bolts are inserted. [18]Instead of screw, there has been use of wing like devices reducing the time of surgery. Since the open technique for the anteroposterior screw was used and there is no report of a median nerve or brachial artery injury.[18]In the retrograde humeral interlocking nailing, an entry hole is made

in the posterior cortex of humerus. The nail is inserted from postero-inferior to an antero-superior direction obliquely .Such a degree of obliqueness stresses the cancellous bone in this area to predispose to iatrogenic fracture at this level. To avoid such an eventuality, a wide and elliptical hole is drilled to be in line of the humeral axis. This should be followed by careful reaming of medulla.[9,38] Thus the nail is inserted eccentrically, because, the nail cannot enter straight into the lower end of the medullary canal as it is covered well by the upper end of ulna.[9 ,29, 43]

In retrograde type, the locking in the end, engaged to the insertion device is usually in the posterior to anterior direction and is safe. However the free end locking in this type of nail insertion (in retrograde method) is also difficult. Image intensifier use in proximal humerus is difficult and a free hand drilling is not easy here.[32,44,50]

To avoid the vital soft tissue structures like the axillary nerve or biceps tendon, retrograde technique should be used in fractures not involving the surgical neck of the humeral head. The technique described is a free hand type. There are nails with no bolts used distally with consequent loss of stability.[38,44-47]The axillary nerve injury due to free end locking is reported.[37]

There is no consensus in following aspects of humeral nailing.

The type of humeral interlocking nails.

Various nails are used since humerus was started to get nailed.[14,48,49]Most initial designs were resembling those for femoral and tibial fractures. Later uniquely designed nails were produced for humerus. With different nail designs, now we have a problem of plenty. However each of these nails is not fully tested. There are two type of nails described principle of stability and biology. The one with locking bolts at the free end is a fixed nails UHN Synthes and one without it is called the bio nails True-Flex Encore.

One needs to compare the result of different series of humeral nailing with regard to the type of the nailing whether fixed or bio .This also decides the speed of rehabilitation e.g fast in fixed.[18]

Irrespective of the type of facture pattern, the fixed nails of choice of the surgeon can be inserted by distal to proximal or proximal to distal direction.[18] But in bio nails the entry must be in the segment closer to the fracture. The stability is given by expansion mechanism in the far end.Thus the free end should be in the longer segment.[50,51] This sort of nails called bio does not per se offer dynamic movement, but they provide rotational stability to some degree. They also have shorter surgery time [38] and less vital structure injury.[18]

As already discussed as there are problems in shoulder due to the intra-articular entry portal, invasion of the rotator cuff, one normally tend to think that such an antegrade entry should be written off. In specific situations where the patient can only operated in supine position e.g in multiply injured, antegrade method is quick, and takes advantage of the ease of using an image intensifier. [18] In wide medullary canal or if patient already has a shoulder problem a retrograde methods is preferred. In young with narrow medulla an antegrade method is preferred. But irrespective of the entry points 'fixed' nailing results are the same, in middle- third humeral fractures in a study.[52]The antegrade and retrograde techniques are not compared and studied with 'bio'-nails.[50,51]As humerus is a non-weight-bearing bone and needs only a nail of minimum diameter that can enter the medullary canal of the distal fragment without difficulty, it does not need the widest (or) strongest nail. Also reaming is the step which during antegrade humeral nailing cause further injury to the rotator cuff with the repeated insertion and withdrawal of several sharp reamers.Trapping by rotator cuff keeps the reamings under it .This causes – post operative heterotrophic ossification and stiffness post operatively.[35,38,53]Heat-induced segmental necrosis and even surgical emphysema can occur after reaming [54-56]Also radial nerve injury can happen if humerus was close to the fracture especially with comminution.

When to do the interlocking nailing?

Interlocking nail was almost immediately done in case of fractures of the shafts of tibia and femur. In those fractures routine reaming causes augmented fracture healing, by the products of reaming. In case of delayed union, dynamization of the fracture site could be done by removing locking bolts on the shorter side fragment. A partial weight bearing can also compress the fracture in fracture femur or humerus.

However in the humerus , as was deliberated, reaming is not advised and such procedure was usually done after failed treatment of plaster immobilisation. This is not immediately done and the advantage of fresh fracture hematoma is lost. Also one cannot load the fracture as like weight bearing of the lower limb as humerus is not a weight bearing bone. So, if one should apply the advantage of lower limb interlocking nailing to the interlocking nailing of humeral shaft fractures , the procedure should be done in acute fractures taking advantage of acute haematoma and minimizing the chances of delayed healing [18]Hence we started this work of acute fracture of humerus shaft.

To compare the results of the nailing procedure, the common view is that whatever the type of nail used or the technique used the results could be compared.[57,58] But there are basically two type of nails, the fixed nails using bolts on either end to achieve stability and the bio devices achieving stability

by means other than bolts. Thus while comparing the nail results, with other methods like plating one should see if the nail was using bolts(fixed) or not (bio).There should be also an analysis on the base of antegrade nailing or a retrograde type nailing[18] It is also impossible to biomechanically compare 'fixed nails using bolts and bio nails- not using bolts.[59,60]

The nails using bolts on either side are naturally are superior in stability when they are compared to those nails that did not use bolts. [18]So, one should formulate biomechanical studies comparing nails with similar biomechanical properties. We need an implant to help in incident free and quick fracture union.[18]One should also compare the type of nailing was retrograde or antegrade.

2. SURGICAL ANATOMY OF HUMERUS

In the upper limb, humerus is the longest tubular bone . The round proximal end becomes tubular in midshaft and flattened in lower end. Upper end has head, neck, greater and lesser tuberosities. The head articulates with the glenoid of the scapula making ball and socket joint. The anatomical neck is a constriction near the articular surface separating it from the two tuberosities.The greater tuberosity is in the lateral part of the upper end of the humerus, while the lesser tuberosity is on the anterior aspect of the bone medial to greater tuberosity.

The two tuberosities are separated from each other by bicipital groove. The humeral proximal end tapers into shaft as a ill-defined surgical neck.

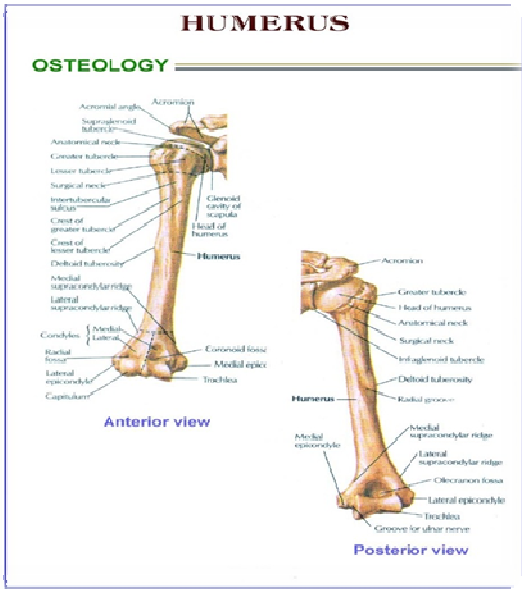


Fig.1. The stucture of humerus bone

The shaft is tubular and forms the major part of the middle of the bone.It extends from the insertion of pectoralis major above to the supracondylar region . The tubular shape proximally changes to triangular distally as shown in the (fig.2) below.

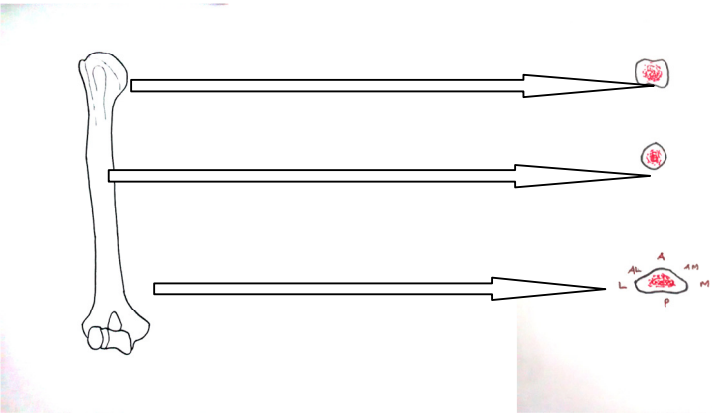


Fig.2. Cross section of humerus bone at upper, middle and lower thirds.

It is at anatomical neck, where the shoulder joint capsule is attached. The three muscles, the supraspinatus, the infraspinatus and the teres minor (Pneumonic -SIT) are inserted from above downwards on the greater tuberosity.

The lesser tuberosity gives attachment to subscapularis. Pectoralis major, the latissimus dorsi and the teres major are inserted into the bicipital groove from before backwards.

The deltoid inserted onto the tuberosity called deltoid tuberosity over the lateral aspect of the middle of the shaft. At this same level but on the medial aspect of humerus shaft, the coracobrachialis muscle is attached.

The anteromedial and the anterolateral surfaces in the lower humerus gives origin to brachialis. The lateral and the medial heads of the triceps arises from posterior surface above and below the bicipital groove.

The medial epicondyle's anterior part gives attachment to the common flexor origin and the lateral epicondyle's posterior part gives attachment to common extensor origin. Lateral supracondylar ridge of humerus gives origin to brachioradialis, extensor carpi radialis longus and extensor carpi radialis brevis.Thus in front, the humerus has coracobrachialis, biceps and brachialis forming the anterior compartment of the arm.These muscles are innervated by musculocutaneous nerve. The posterior aspect of humerus has triceps forming the posterior compartment It is innervated by radial nerve.In the upper half, on front ,lateral,back the humerus has deltoid muscle cover innervated by the axillary nerve.

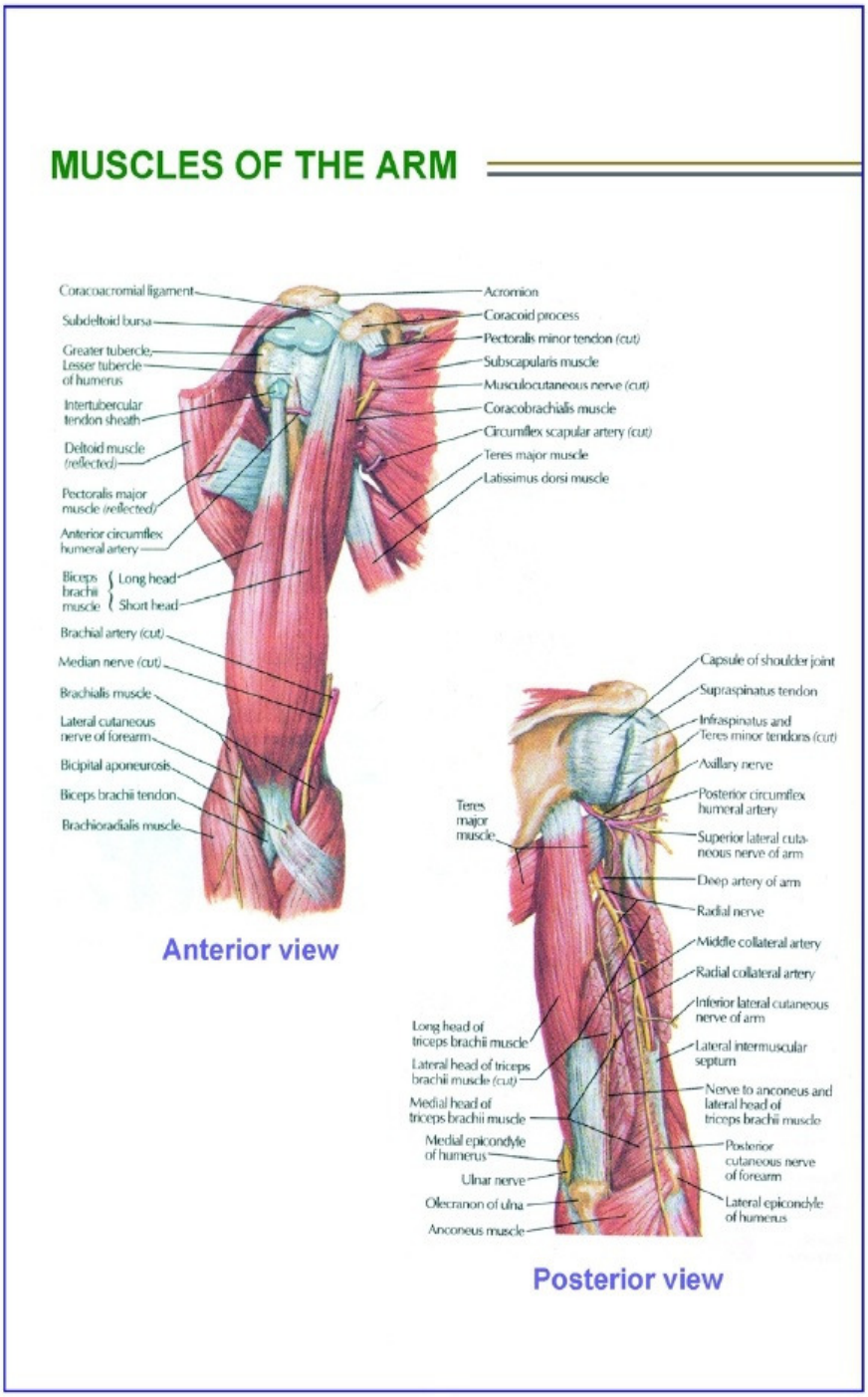


Fig : 3. The soft tissue relationship of humerus bone

NEUROVASCULAR RELATIONS:

Three important neurovascular bundles lie close to humerus. The axillary nerve runs around the proximal metaphysis of the humerus supplying the deltoid. It is about on an average 4.56 cms from the lateral edge of the acromion. This is important while inserting the proximal locking screw as shown in the figure no. 4 below.

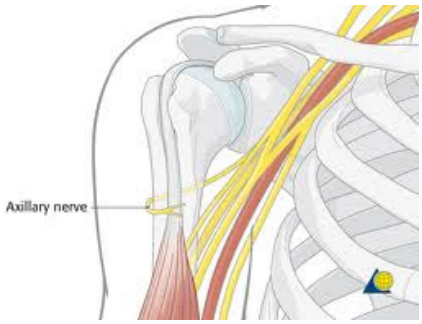


Fig : 4. Neurovascular reltionship of axillary nerve in upper third of humerus

The radial nerve is accompained by the profunda brachial vessels. It runs around the posterior aspect of the humerus in the radial groove. On either side of this the medial and the lateral head of the triceps.

Thus it may get entrapped in the fracture, causing radial nerve palsy called Holstein lewis syndrome.This is because the radial nerve is least mobile as it passes through lateral intermuscular septum in distal third

of arm (fixed to proximal fragment by lateral intermuscular septum) is trapped between fragments when closed reduction is attempted.

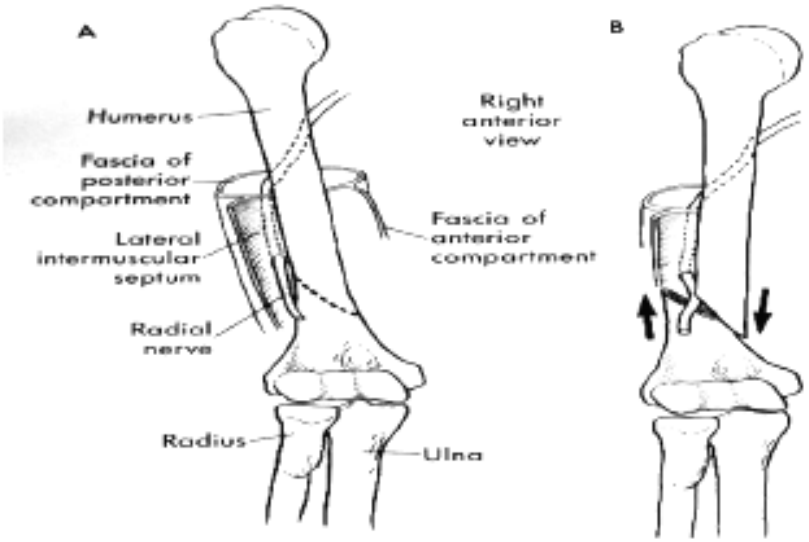
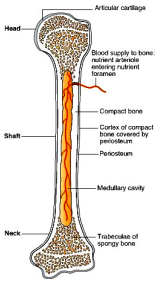


Fig. 5. Holstein - Lewis Fracture

The brachial vessels, the median, the ulnar nerve and the medial cutaneous nerves of the arm and forearm run in the space between the biceps and the brachialis.

BLOOD SUPPLY :

The nutrient artery of the humerus arises usually about the middle of the arm from the brachial artery.It enters the nutrient canal near the insertion of coraco-brachialis and is directed downwards**.**Occasionally another nutrient artery from profounda brachii enters the humerus proximal to deltoid tuberosity.



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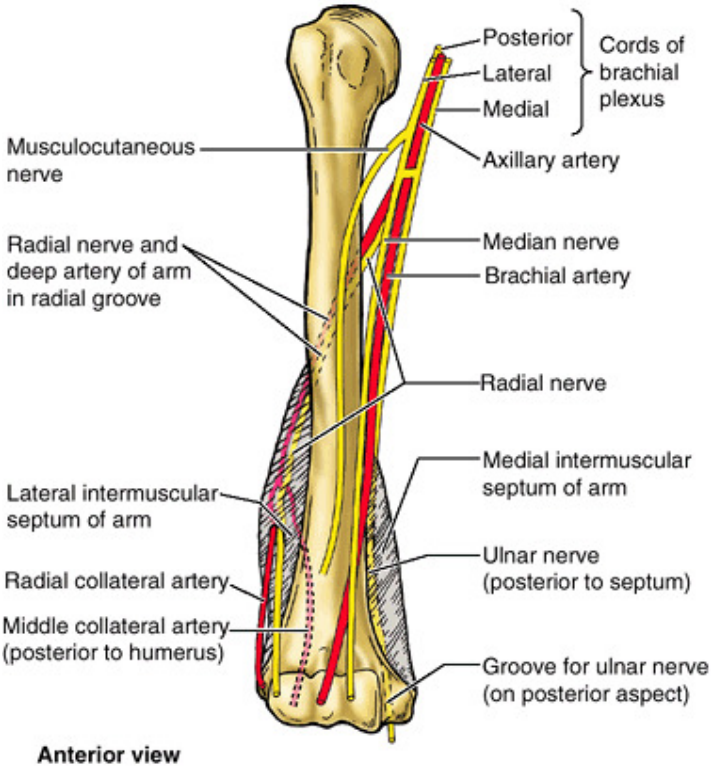


Fig : 7

Thus fractures through the shaft of humerus at the junction of middle and lower third may destroy the main nutrient artery during injury.

This may be one of the reasons for the delayed or non-union of the fractures at middle or lower one-third junction of shaft.

The shaft of the humerus has unique features affecting the mode of treatment of these fractures.

The humerus functions mainly as a lever and is not as a bone which bears weight. The compression forces do not affect the treatment method in humerus fractures. Gravity assist the fracture reduction by the dependency in semi erect position.

The entry portal for interlocking nail, may theoretically cause damage to the rotator cuff result in shoulder pain and restriction of movement.

3. MECHANISM OF INJURY OF HUMERUS SHAFT FRACTURES, CLASSIFICATION, BIOMECHANICS AND PRINCIPLES OF HUMERUS FRACURES MANAGEMENT.

3.1. MECHANISM OF INJURY OF HUMERUS SHAFT FRACTURES

Humeral shaft fractures result from either direct or indirect trauma, motor vehicle accidents being the most common cause.Falls on the outstretched hand and direct loads to the arm are other mechanisms for these fractures as shown in the figure below. It can occur due to strong muscle contraction or even while throwing a javelin in sports. The elderly patients who sustain humeral shaft fracture due to fall often have less comminuted fracture patterns. Greater amounts of comminution and soft tissue trauma result from high energy injuries.Pure compressive forces result in proximal or distal humeral fractures. Bending forces result in transverse fractures of the shaft of humerus.Torsional forces result in spiral fracture patterns.The combination of bending and torsion resilts in oblique fractures ssassociated with butterfly fragment.

FRACTURE DISPLACEMENT IN HUMERUS FRACTURES:

The main muscular force acting on the humeral shaft,after fracture causes the fracture deformities. If the fracture is proximal to the pectoralis major muscles attached in the rotator cuff muscles pull the proximal fragment, the distal fragment is pulled medially by the pectoralis major as shown in the figure no. 9A below.

If the fracture occurs distal to the pectoralis major attachment and proximal to the deltoid insertion, the distal fragment is laterally displaced by the deltoid, while the pectoralis major, latissimus dorsi and teres major displace the proximal fragment medially as shown in the figure no. 9B. When the fracture is distal to the deltoid insertion, the proximal fragment is abducted and flexed while the distal fragment is proximally displaced (Fig. 9C).

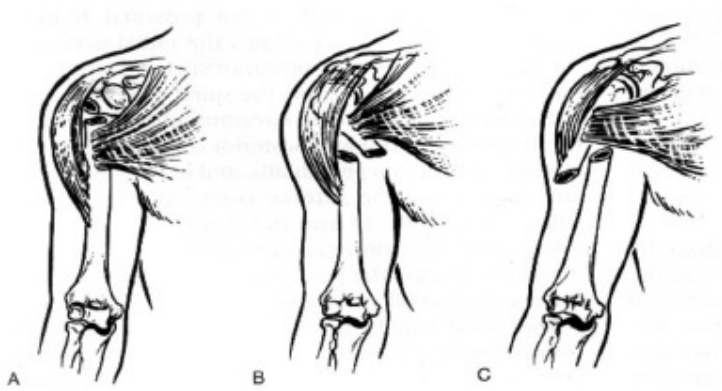


Fig : 9 Displacement depending on level of fracture

3.2.CLASSIFICATION OF HUMERAL SHAFT FRACTURES

There is no universally accepted classification system for humeral shaft fractures. Classically, humeral shaft fractures have been classified on the bas is of various factors that influence treatment such as:

1a. Fracture location in which third of humerus shaft

a. Proximal third

b. Middle third

c. Distal third

1b. Fracture location in relation to major muscle attachments

a. Fracture proximal to pectoralis major insertion

b. Fracture distal to pectoralis major insertion but proximal to the deltoid insertion

c. Fracture distal to the deltoid insertion.

2. Direction and character of fracture line

a. Transverse

b. Oblique

c. Spiral

d. Segmental

e. Comminuted

3. Associated soft tissue injury

a.Closed fracture

b.Open fracture

4. AO/ASIF classification of the humeral diaphyseal fractures

AO/ASIF has an elaborate system of classification of the fractures based on the fracture morphology, and the fracture site. This comprehensive classification gives prognostic value, grade of fractures,energy of injury and the chances of occurrence of complications during treatment.

Type A Simple fracture

A1 Simple fracture, spiral

A1.1 proximal zone

A1.2 middle zone

A1.3 distal zone

A2 Simple fracture, oblique (>30°)

A2.1 proximal zone

A2.2 middle zone

A2.3 distal zone

A3 Simple fracture, transverse (<30°)

A3.1 proximal zone

A3.2 middle zone

A3.3 distal zone

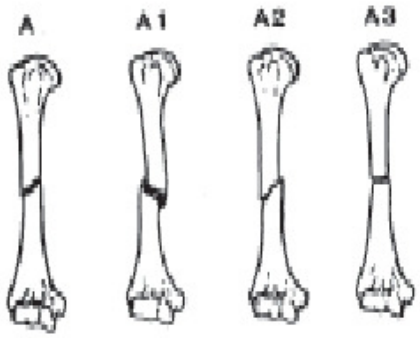


Fig : 10

Type B Wedge fracture

B1 Wedge fracture, spiral wedge

B1.1 proximal zone

B1.2 middle zone

B1.3 distal zone

B2 Wedge fracture, bending wedge

B2.1 proximal zone

B2.2 middle zone

B2.3 distal zone

B3 Wedge fracture, fragmented wedge

B3.1 proximal zone

B3.2 middle zone

B3.3 distal zone

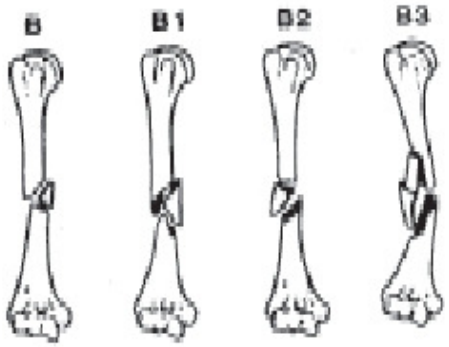


Fig : 11

Type C Complex fracture

C1 Complex fracture, spiral

C1.1 with two intermediate fragments

C1.2 with three intermediate fragments

C1.3 with more than three intermediate fragments

C2 Complex fracture, segmental

C2.1 with one intermediate segmental fragment

C2.2 with one intermediate segmental and additional wedge fragment(s)

C2.3 with two intermediate segmental fragments

C3 Complex fracture, irregular

C3.1 with two or three intermediate fragments

C3.2 with limited shattering (< 4 cm)

C3.3 with extensive shattering ($\geq$ 4 cm)

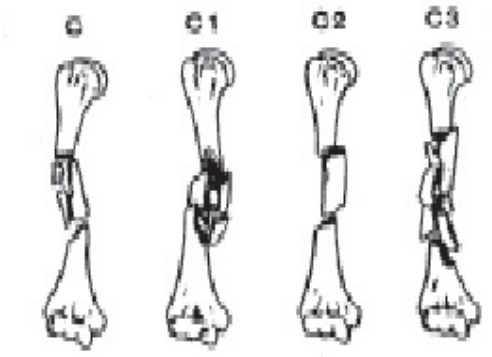


Fig : 12

METHODS OF TREATMENTS

The aim of humeral shaft fracture is to achieve union with an acceptable humeral alignment and restore the patients to their preinjury status.Various techniques were described for the management of humeral shaft fractures.One has to not only consider the factors (age,associated injuries, soft tissue involvement but also the fracture pattern) this is vital to achieve good results.

Most fractures are treated conservatively .The methods of treatment are

1.Dependency traction by hanging arm cast U-shaped brachial splint and Thoracobrachial immobilization.

Thoracobrachial immobilization method method offers immediate splinting the fracture against the thorax to provide stability and promote union example Velpeau bandage,thoracobrachial spica cast and sling and swathe immobilization.

Functional cast bracing is yet another technique.

SURGICAL METHODS:

1. External fixation
2. Plate and screw fixation
3. Intramedullary nailing

CONSERVATIVE MANAGEMENT:

Many fractures of the humeral diaphysis is managed conservatively, had Successfully united with good functional outcome.

1. DEPENDENCY TRACTION :

These methods of closed treatment depend on gravity to assist in alignment. Caldwell in 1933, started using this dependency traction provided by the weight of the cast to achieve fracture reduction.This method is indicated in midshaft fractures with shortening, particularly those fractures with an oblique or spiral pattern as there is an element of cortical contact as shown in the (fig.13 and 14) below. This method is contraindicated in transverse fractures as there is a potential for distraction and healing complication. This treatment with the hanging arm cast requires careful patient selection and a co-operative patient with closed monitoring of X-rays.

Fig.13 Obilque fracture

Fig. 14 Spiral fracture

U-shaped brachial splint :

It involves applying well molded plaster slab from the axilla, around the elbow and over the deltoid with the elbow flexed to 90°.

In addition a collar and cuff suspension sling supports the forearm.

This method has fewer tendencies for distraction. The advantage of the U shaped splint lies mainly in its universal application. However with this U slab patient cannot extend the elbow. Also the plaster irritates axilla and is heavy.

THORACOBRACHIAL IMMOBILIZATION:

This is splinting the fractured humerus against the thorax to provide immediate stability and promote union. It however cannot control alignment . They have no place in the current treatment of humeral fractures.(e.g)The example of a thoraco brachial immobilization is the stockinette velpeau shoulder dressing was described by Gilchrist for immobilization of the shoulder girdle.

In these cases the main concern is,patient comfort and not fracture reduction. It is cheap could be applied easily .This can be only used in minimally displaced fractures in patients at extremes of ages who cannot tolerate other methods of management.

Shoulder spica cast not used nowdays because of cast weight and bulkiness.

FUNCTIONAL BRACING :

Sarmiento, the father of functional cast bracing described the treatment method for humerus fractures in 1977 .Fracture reduction is achieved by soft tissue compression.This device allows shoulder and elbow motion. Studies have shown 87% to 90% union with treatment by functional cast bracing.

However functional cast is contra-indicated in case of

1. massive soft tissue injury
2. bone loss
3. un-cooperative patient and
4. unacceptable fracture alignment

INDICATIONS FOR OPERATIVE TREATMENT

The indications for operative management of humeral shaft fractures are, humerus fracture in multiple injured patient segmental fracture, pathologic fracture, bilateral humerus fractures, fractures with unacceptable alignment, radial nerve dysfunction after fracture manipulation(Holstein Lewis syndrome), neurologic loss after a penetrating injury, associated vascular injury , open fracture, floating elbow.

The different operative methods available are : External fixation and Internal fixation

External fixation

The external fixation is done by unilateral frames or by ring type of fixators with 1.8mm diameter tensioned wires. The indications for external fixation of humeral shaft fractures include, open fractures with extensive soft tissue injury, fractures with associated burns and infected nonunions. Complications with external fixation include, pin tract infection, neurovascular, tendon muscle impairment and nonunion. These can be avoided by meticulous operative technique.

Internal fixation

The methods are plate osteosynthesis and intramedullary fixation.

Plate osteosynthesis

This achieve anatomical reduction and stable fixation requires extensive surgical exposure like anterolateral, anterior or posterior approaches. In average to large sized patient a 4.5mm broad dynamic compression plate (DCP) is used. Fixation of eight to ten cortices proximal and distal to the fracture should be obtained. Bone grafting is required if there is comminution and soft tissue injury.

Intramedullary fixation :

An intramedullary nail is satisfactory for most diaphyseal fractures of long bones. Intramedullary nails offer several advantages over plates and external fixations.

1.Because the intramedullary canal is closer to the mechanical axis than the usual plate position on the external surface of the bone, nails in the canal confirm less bending loads than plates and chances of failure is less .

2. Intramedullary nail is a load sharing device in fractures with cortical contact.

3.In mid shaft fractures,they fill the medullary canal and re-establish osseous alignment.

4.Stress shielding with resultant cortical osteopenia, commonly seen with plate osteo synthesis causing fracture after implant removal is rarely seen after intramedullary nails.

Two types of intramedullary nails are available for use in humeral shaft fractures**:**

A).Flexible Intramedullary nails

example - Ender nails

- Hackethal nails

- Rush rods

With these devices, multiple implants are required to achieve fracture stability.

They do not provide rigid fixation or prevent fracture shortening nor rotational control.

B). Rigid inter locked intramedullary nails

These nails relay on proximal screw and distal screw fixation to provide stability.

C). Nails with distal screw fixation

example - Russell - Taylor nail

- AO unreamed humeral nail. (UHN)

Locked intramedullary nails maintain alignment of unstable fracture patterns, prevent fracture shortening and rotation.

They are used to stabilize humeral shaft fractures happening 2cms from surgical neck to 3cms proximal to the olecrenon fossa.

3.3.BIOMECHANICS OF INTRAMEDULLARY NAILING

An intramedullary nail being located in the center of the bone provides rigid and temporary stiffness to the bone. It acts as an internal splint and works as a load-sharing device, permitting load transmission across the fracture site and thus promoting fracture healing. These nails are best suited to control the bending and translational stresses. Interlocking screws are effective in controlling the rotational stress on the bone.

During the period of fracture healing, internal fixation aids in transmission of forces from one end of the fractured bone to the other end, thereby producing stresses in the implant.

The mechanical behavior of the implant is determined by both material and geometry. The rigidity or stiffness of a cylindrical structure in bending and torsion is proportional to the fourth power fo the radius (i.e., the polar moment of inertia). The more force is distributed in the bending or tostional axis, the stiffer the structure becomes.

Working length is the vital parameter that decides the outcome of fixation. It is the length of the nail that bridge the fracture site from its distal most point of fixation in the proximal fragment to the proximal most of fixation in the distal fragment as shown in the (fig.15) below. This otherwise mean the length of the bone carrying the load across the fracture site.

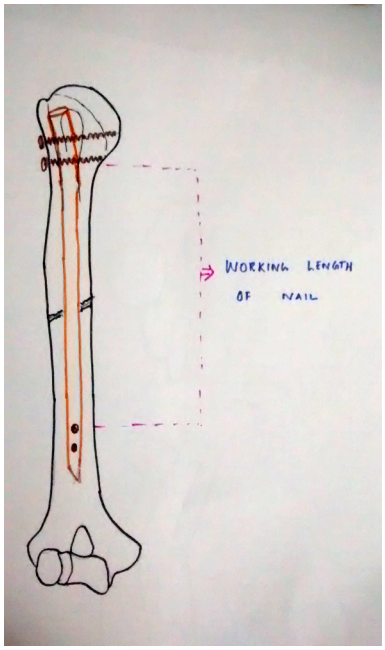


Fig : 15.

Bending Stiffness $\propto$ 1 /$\sqrt{}$ (working length)

Torsional stiffness $\propto$ 1/ (working length)

STATIC LOCKING AND BRIDGING FIXATION

Inter locking bolt at the proximal and distal fragment of the fracture renders rotational stability to the fracture site by the interlocking nail. This is vital as the stresses are more of a rotational type rather than a compression distraction type.

Static locking in static mode gives a bridging fixation, especially in comminuted fracture where the position of locking bolts in farther away from the fracture site. This type of fixation is useful in communition, delicate soft tissue cover, long oblique and spiral fractures. In the above condition opening of fracture will devascularize the fracture fragment.

THE CONCEPT OF FRACTURE HEALING BY CLOSED INTRAMEDULLARY NAILING

After a closed intramedullary nailing fracture healing happens by periosteal callus. As closed nailing is not exposing the fracture preserves the fracture hematoma which is vital for fracture healing.Periosteum accounts for the vascularity of outer one-third of the cortex of shaft. In comminuted fractures,the soft tissue attachment is the source of vascularity of the comminuted fragments.

Open reduction further hampers the blood supply by stripping the periosteum and soft tissues of the bone in these comminuted fractures.

Thus closed nailing preserves periosteal blood supply and promote fracture union by the osteogenic potential of the pluripotent cells in the fracture hematoma. Thus closed intramedullary nailing is a biological fixation.

Blood loss is minimal and rate of infection is less with less days of stay in hospital.

3.4. PRINCIPLES ININTERLOCKING INTRAMEDULLARY NAILING

Interlocking intramedullary nailing is a safe and effective means of fracture fixation. It allows early mobilization for the neighbouring joints by the stability of fixation.

This biological means of fixation aims at providing early useful movements of the extremity. Good preoperative planning and careful operative technique with adequate instrumentations and skilled intraoperative images are of utmost importance.

Preoperative injury films must be carefully inspected for the characterstics fracture pattern, its degree of comminution, the measurement of medullary canal size,any deformity and presence of associated injuries.

Closed nailing is prefered when fracture could be reduced.The main step the entry into the proximal nail insertion is a critical step in closed nailing.

If not properly done, it results in angular deformity at the fracture site or comminution during reaming or nail insertion.

Entry port is medial to the greater tuberosity, this make an angle of 5° with the medullary canal the proximal portion of the nail is angled.

With antegrade insertion, it is also vital that proximal end of the nail is well burried under the bone surface to prevent nail, irritating on the nail on the subacromial soft tissue. If possible interlocking intramedullary nailing must be performed within few hours of injury, before the onset of soft tissue shortening and oedema.This makes fracture reduction easier. Union is the main objective of any surgical procedure.

Just fixing a nail is not a good substitute for fracture reduction and hence union.

As the three principal factors of fracture union are

1.viability - vascularity of ends

2. Contact - reduction

3.stability - nailing

REQUISITE MATERIAL PROPERTIES OF THE IMPLANT

For such nails the material that is used should be biocompatible to evade corrosion and to stresses.

The more common material that are used for implants of fracture fixation being 316L stainless steel and titanium alloy.

316L stainless steel consists of iron, 17% chromium, and12% nickel,

3% manganese and 2% molybdenum with <0.03% carbon.

316 L stainless steel has modulus of elasticity close to the human bone.

It also resist corrosion by forming an oxide film. It also has good resistance to fatigue from cyclical loading.

4. AIM OF THE STUDY

To evaluate the effectiveness of closed reaming antegrade interlocking nail in humeral diaphyseal fractures in adults.

5. MATERIALS AND METHODS

Our study is a series of 31 cases of acute humeral shaft fractures treated with closed intramedullary interlocking nailing.

This study was conducted over aperiod of 2 years from July 2012 to June 2014

5.1 SOURCE OF DATA :

The source of data were inpatients at Thanjavur medical college and Hospital, Thanjavur.

5.2 STUDY SUBJECTS :

Study subjects were adult patients with fracture shaft of humerus.

5.3.INCLUSION CRITERIA :

Patients were selected based upon following criteria,

1.Age more than 18 yrs (skeletally mature).

2.Fractures of humeral shaft from 3cm proximal to the olecranon fossa to within 2cm of the surgical neck of the humerus.

3.Unsatisfactory reduced conservative immobilisation.

4.Humerus shaft Fractures in multiple injured patients.

5. Closed fractures and grade I open fractures of humeral shaft.

5.4.EXCLUSION CRITERIA :

Patients aged 17 years or below, when the physis is still open.

Humeral shaft fractures involving the proximal 2 cms and distal 3 cms ofthe humerus.

Grossly contaminated, open fractures - Grade II, III

5.5 PROTOCOL

A careful history was elicited from the patients and attenders on the the mechanism of injury and the severity of injury. Then clinically assessed to evaluate the general condition of the patient and local injury is done.

The vital signs were recorded and associated injuries were also carefully looked for.

Local examination was done to find the signs of fracture like, swelling, deformity, tenderness. However due to acuteness of fracture purposeful abnormal mobility of fracture is not elicited. Also associated neurovascular deficit was recorded.

Radiographs of the affected arm including shoulder and elbow joints were taken in antero-posterior and lateral views.

The limb was temporarily immobilised in a U-slab with collar and cuff sling and analgesics were given.

An informed consent was obtained after telling details of operative procedure, operative procedure, its advantages and likely complications to the patient and informed consent was obtained.

All necessary blood investigations (complete blood count, blood urea, serum creatinine, blood sugar, HIV, HBSAg) , ECG and if necessary chest X-ray were done. Physician's fitness for surgery was obtained.

All the cases were treated by closed intramedullary interlocking nailing in antegrade manner.

Pre-anesthetic checkup was done for all patients

5.6.PRE-OPERATIVE PREPARATION :

The radiographs of the limb were carefully studied upon and technical aspects of the surgery were planned, like medullary canal diameter from radiographs and also to select proper the length and diameter of the nail to be used. The length of the nail is selected clinically by a measurement from greater tuberosity to the elbow crease in flexion of 90° in the uninjured limb. An appropriate nail set is got ready and autoclaved.

5.7.INSTRUMENTS REQUIRED FOR THE PROCEDURE :

Apart from general surgical instruments, following instruments are required as shown in the figure no. (16 to 23).

INSTRUMENT SET FOR INTERLOCKING NAIL

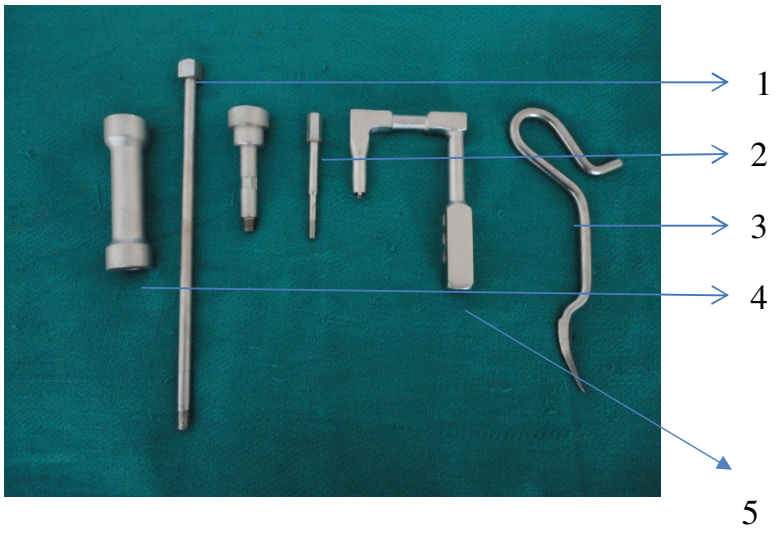


Fig : 16

1. Connecting rod 2. Nail connecting rod

3. Bone awl 4. Hammer device

5. Proximal jig

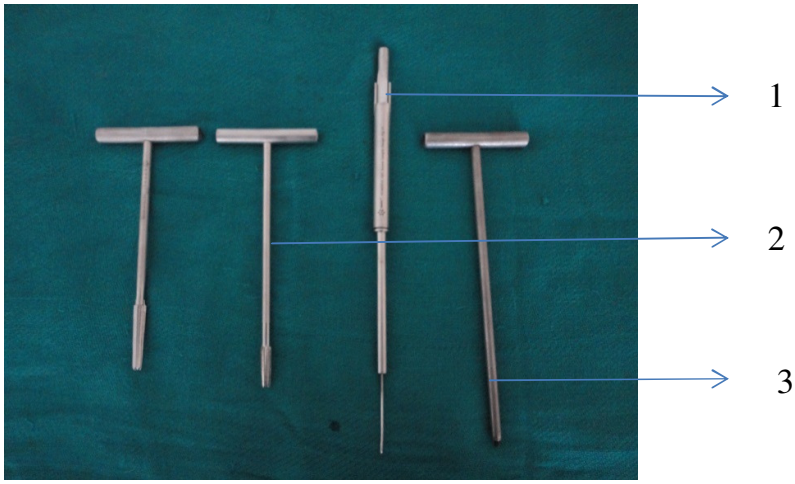


Fig : 17

1. Depth gauge 2. Proximal reamer 3. Hexa -screw driver

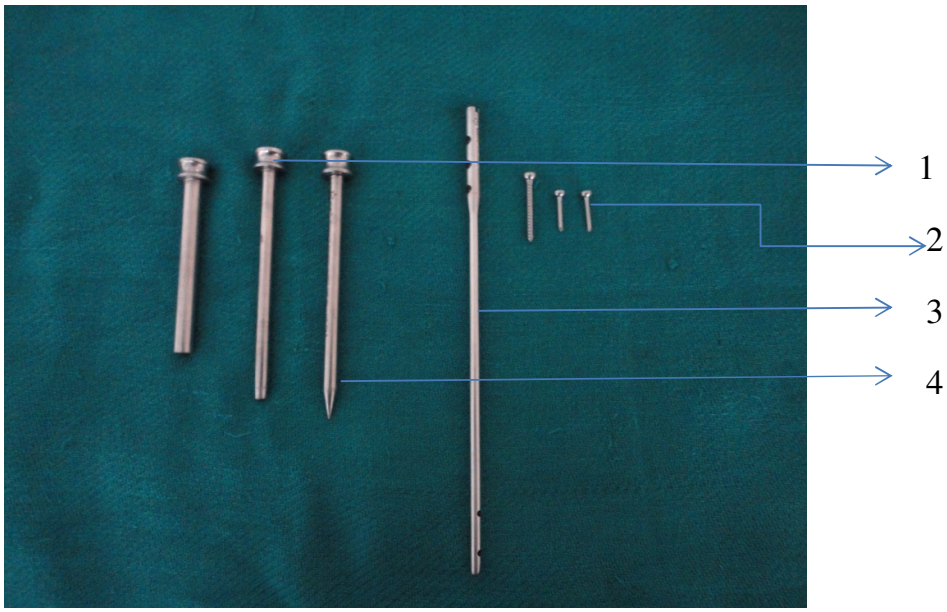


Fig : 18

1. Centralizer drill guide 2. Interlocking bolt

3. Interlocking nail 4. Trocar

Fig : 19

DHS guide wire

Fig : 20

DHS core reamer

DHS guide wire used for initial reaming of proximal fragment.

Fig : 21

Nail set box

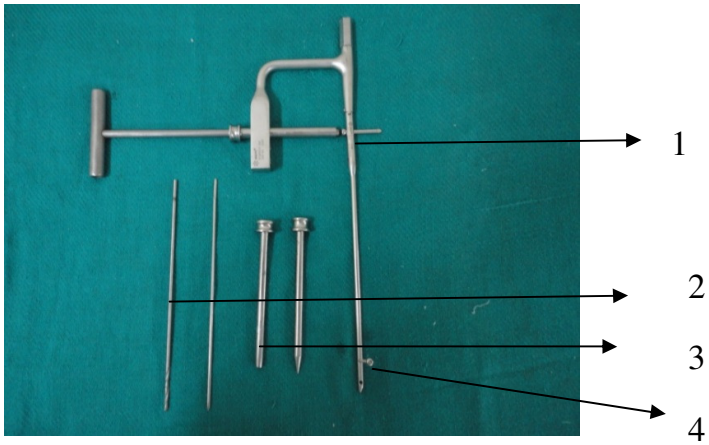


Fig : 22

Nail mounted with proximal jig

1. Proximal interlocking bolt 2. Drill bit

3. Centralised drill sleeve 4. Distal interlocking bolt

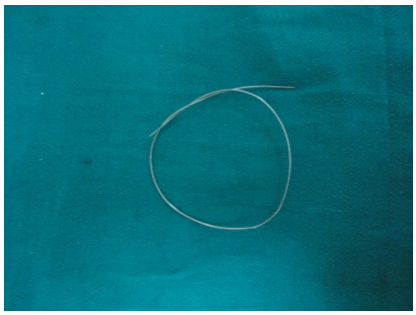


Fig : 23 Guide wire

The ends are approximated to enable positioning inside autoclave bin.

- Proximal Jig
- Conical bolts - noncannulated / cannulated
- Wrench
- Bone awl /Mallet
- Supine drive
- Extraction set
- Drill bits - 2.5mm / 3.2mm
- Protection sleeve, Drill sleeve and Trocar
- Guide wire
- Screw depth gauge
- Hexagonal screw driver

Image intensifier is also needed.

5.8.IMPLANT DESIGN

We use nails were AO type humeral interlocking nails made of stainlessteel 316L of diameters 6mm,7mm and 8mm. The 6mm and7mm nails are solid while the 8mm nails are cannulated, hich can be inserted over a 2 mm guide wire.

These nails are available in varying lengths from 200mm onwards at an increment of 10mm. In order to negotiate the fracture site and entry into the medullary canal of distal fragment the distal end is bevelled. They have minimal bend of 5° at a constant distance at proximal end to allow eccentricity of the entry point. The nails will have an internal thread at its proximal end to seat the locking nut in the jig.The proximal end of the nail is wide and has holes for the thicker locking screws. These slots are circular slots allow static locking. The proximal locking screws are inserted in a lateral to medial direction with the help of jig.

The distal end of the nail has two circular slots for static locking of the distal locking screw in anterior to posterior insertion of the locking screw by free hand technique.

These locking bolts are trocar tipped and self cutting cortical screws of 2.5mm diameter for 6mm nail and 3.5mm diameter for 7mm and 8mm nails.

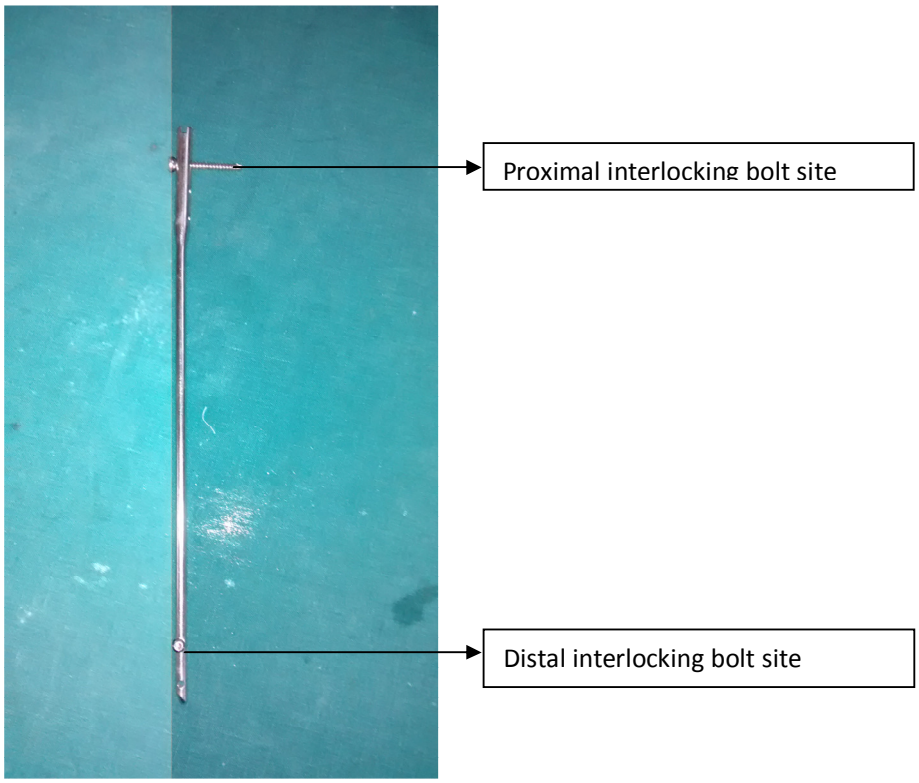


Fig : 24 Interlocking nail with sites of interlocking bolts

OPERATIVE TECHNIQUES

The extremity including axilla was shaved and prepped. Patients were kept fasting from 6 hours before surgery. The prophylactic antibiotic was given just before skin incision.

Patient is placed in beach chair position as shown in the (fig. 25) below, with affected arm draped fully. No opsite was used. A sand bag is placed underneath the scapula for good exposure of the entry point. Patient is brought to the edge of the table. Image intensifier brought laterally to focus on the injured side shoulder. Patient head is placed on head rest and turned to opposite side. Before proceeding with the surgery, good radiographic imaging of entire humerus is done. For this the arm site block of the radiolucent table is removed for proper access to shoulder and arm. Surgeon stands at the top of the bed looking down on the shoulder. Assistant on the other side holding the arm.

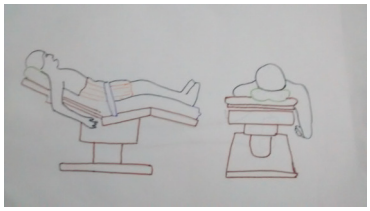


Fig : 25 Beach chair position

Entry point is started with the DHS guide wire. Guide wire is placed just medial to the tip of greater tuberosity, anterior to acromion process and

lateral to articular surface, into the proximal humerus and confirmed with image intensifier. Minimal incision made at the point of guide wire. The guide wire is passed into the medullary canal under image guidance. Both antero posterior and lateral views checked. Then reaming is started with DHS core reamer. This opens the proximal fragments medulla for manipulation of the interlocking nail guide wire.

Fracture is reduced with gentle longitudinal traction with forearm in supination and by manipulation. Ball tipped guide wire passed into the proximal fragment and passed across fracture site under C-arm guidance and arm rotation. The position of the guide wire is checked in two planes both anteroposterior and lateral. Then reamed with reamer in increment of size.

Nail of size 1 mm smaller in diameter than reamer is chosen. Nail is buried well into the head. First the distal interlocking is done with free hand technique.

Distal locking is done in anteroposterior direction by free hand technique. A 2-cm longitudinal incision is made just lateral to the biceps tendon and centered over the distal locking slot in the nail. Soft tissues are dissected bluntly down to the bone.

The arm is rotated until the slot is seen as a big hole in the image intensifier.

First a Steinmann pin is placed at the site of distal locking as seen in the image intensifier and a starting point made by a blow with a mallet. This site in them drilled for the two cortices and a appropriate self tapping screw is passed with a hexa screw driver.Then reverse banging is done to impact fracture. Proximal locking is done in lateral to medial direction with the help of jig. The screw slot site in them drilled and a appropriate self tapping screw is passed with a hexa screw driver.

After locking, proper positioning of the screw can be confirmed under image intensifier.

For unreamed nail of 6mm and 7mm diameter proximal reaming done as above.The nail is passed with jig across the fracture into the distal fragment with traction applied.

Closure :

The jig is removed, and the wound is closed in layers without drain.

Post operative management.

Post operatively, the arm is placed in a sling and early range of motion exercises for shoulder and elbow were started as soon as the pain subsided, to avoid stiffness. In patients without associated injuries or did not need hospital stay, were instructed regarding range of motion exercises and were discharged on 5th postoperative day. The suture removal was done on 14th postoperative day as outpatient.

Follow up

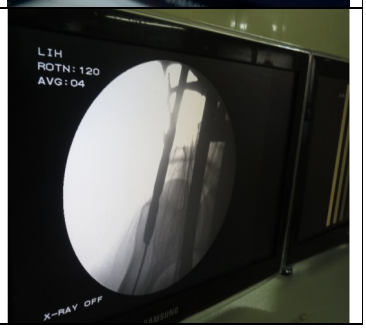
All the patients were followed up at monthly intervals for the period of 6 months or till the union of fracture .Special stress is laid on shoulder and elbow range of movements and subjective complaints. Radiographs were taken both in antero posterior and lateral views to check for signs of union. The patient was asked to avoid driving two wheeler and lifting heavy weight.

Assessment of results

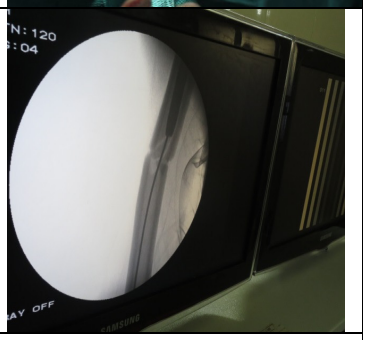
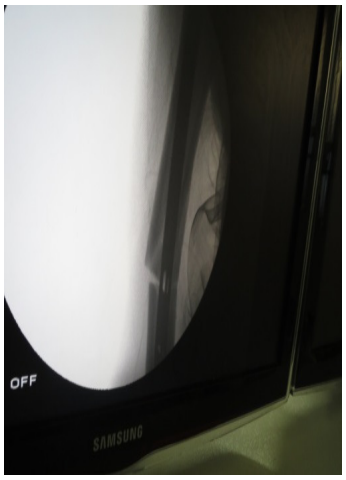
Assessment of the patient was done on the basis of clinical and radiological union, range of motion at shoulder and elbow joints and subjective complaints like pain in shoulder and elbow joint.

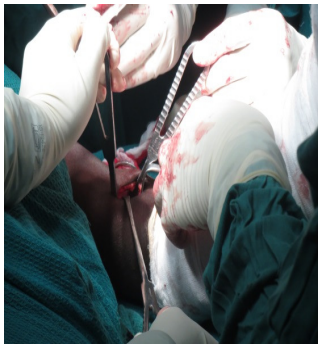
THE STEP BY STEP PROCEDURE WITH AVERAGE TIME IS GIVEN BELOW

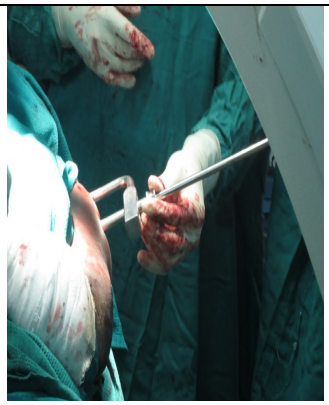
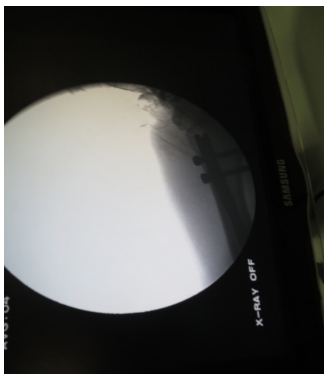
After general anaesthesia/supraclavicular block

S. NO	STEPS	Average time taken (in minutes)	
1.	Painting	5	
2.	Draping	5	
3.	Passing a guide wire	10	
4.	C-arm image of passing DHS reamer	3	

5.	Entry of guide wire	1	
6.	Guide wire crossing the fracture site after manipulation	1	
7.	Reamer passed over guide wire	3	
8.	Reamer crossing fracture site	2	

9.	Reamer passed up to distal end of humerus	1	
10.	Insertion of nail	5	
11.	Nail passing over guide wire in proximal fragment seen with C-arm	1	
12.	Nail crossing fracture site	2	

13.	Distal interlocking bolt fixation by free hand technique & Distal most hole is drilled with2.7mm drill bit	10	 
14.	Image showing distal interlocking screw fixation	1	

15.	Proximal interlocking using proximal jig	5	  
16	Total procedure from draping to distal locking	55 minutes	

ILLUSTRATIVE CASES

CASE 1-

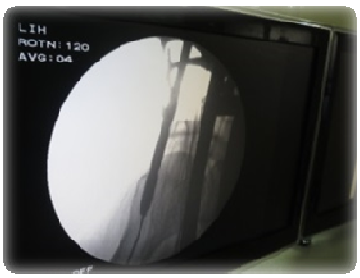
Mr. M, 45 year old gentleman was received in the emergency ward after his two wheeler was hit by a car. On examination he was conscious, oriented and he did not have any loss of consciousness. He had no other significant injuries. His vitals were stable. Local examination revealed gross swelling and abnormal mobility of the left arm.

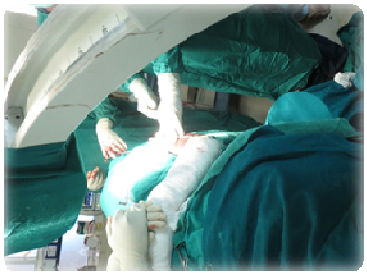
X-rays of the left arm with shoulder antero-posterior and lateral views (fig 27.) were taken, they revealed a fracture of the middle third shaft fracture humerus. The type of the fracture was Muller type 12A2. The fracture was initially stabilised with a U-Slab (fig 26.)

Fig 26: Clinical photograph

Fig 27:Pre-operative X- rays

He was taken up for surgery on the 7 th day.A closed reduction and internal fixation with interlocking nail was done.Figures 28 to 31 to shows the intraoperative findings.





Figures: 28 and 29 reaming of proximal medulla of humerus under C-arm control

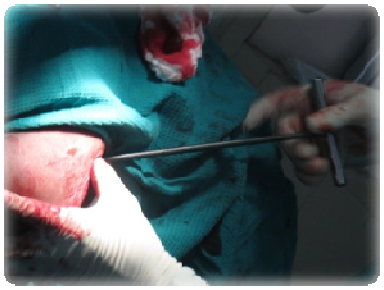


Fig 30 .Reaming of the distal humerus over a guide wire

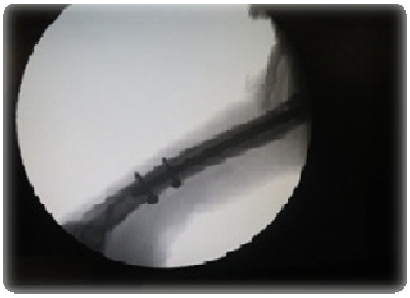


Fig 31. C-arm confirmation of distal locking

He was given postoperative intravenous antibiotics and dressings . Physiotherapy in the form of gentle pendulum excersises for shoulder and elbow mobilisation exercises were started . He was reveiwed after 3 weeks.

At 14 weeks follow up ,he had acceptable shoulder range of motion of almost 80º(fig. 32 and 33) and X-rays showed evidence of radiological union in the form of callus formation.(fig.38 and 39).

Fig. 32
Post operative abduction

Fig. 33
post operative abduction

Patient followed up at 14 weeks .He had acceptable range of movement in abduction.

Fig. 34
Post operative external rotation

Fig. 35
Post operative internal rotation

Patient followed up at 14 weeks. He had acceptable range of movement in external and internal rotation as shown in the figures above (Fig. 34 and 35).

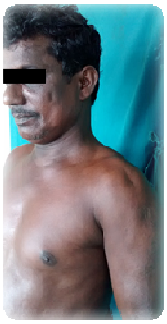


Fig. 36

Fig. 37

Post surgical scar site

Healthy post surgical scar of the patient at the entry site, proximal interlocking site and distal interlocking site as shown above in the (fig. 36 and 37).

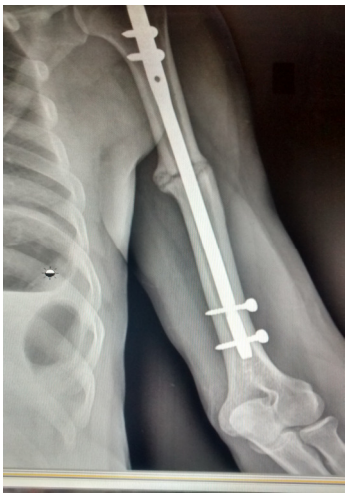


Fig. 38

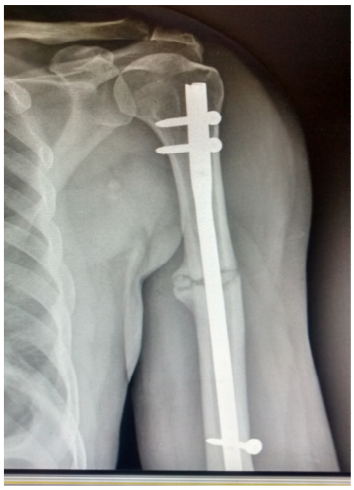


Fig. 39

Follow up X- rays

This patient followed up at 14 weeks and X-rays shown above (fig. 38 and 39) reflect the callus formation, fracture union and proximal part of the nail being buried well into the head.

ILLUSTRATIVE CASE 2

This 33 year old gentleman Mr K, had wall collapse in his house. On examination he was conscious and oriented and his vitals were stable. His local examination revealed gross swelling and abnormal mobility of the left arm.

Fig. 40: Preoperative clinical photograph

X-rays of the left arm with the shoulder AP and lateral (fig. 41) views were taken. They revealed the middle third shaft fracture of humerus. The type of the fracture was AO type 12A3. The fracture was initially stabilised with a U -Slab (fig. 40).

Fig. 41: Pre-op X-rays (AP view)

He was taken up for surgery on the sixth day post injury .The shaft fracture humerus was fixed using a closed antegrade reamed interlocking nail .

He was coming regular follow ups and his radiographs are shown in figures

Later he went on to the union of the humerus fracture in 3 months 14 days but he had occasional pain in his left shoulder with 90º abduction at the shoulder (figs.42, 43 and 44).

Fig. 42

Post operative abduction

Fig. 43

Post operative abduction

Fig. 44

Post operative abduction

Patient followed up at 14 weeks . He had excellent range of movements in abduction as shown in the above .(Fig. 42, 43 and 44)

Fig. 45

Post operative external rotation

Fig. 46

Post operative internal rotation

Fig. 47

Post operative extension

Patient followed up at 14 weeks. He had excellent range of movements in flexion , extension , internal and external rotations as seen in (fig. 45,46 and 47) above.

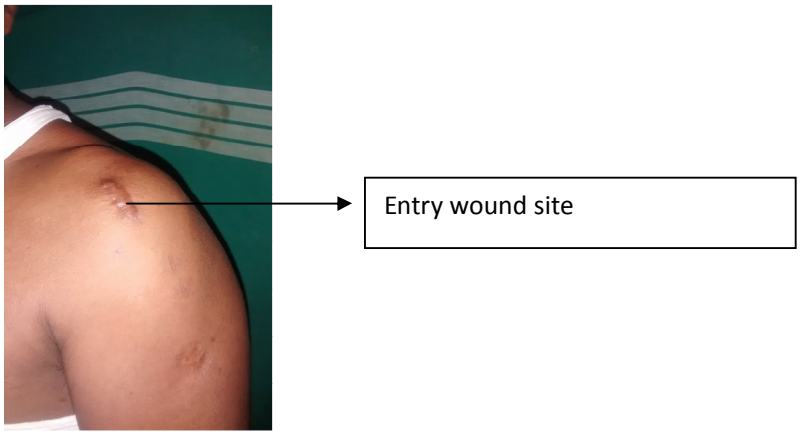


Fig. 48

Post surgical scar site

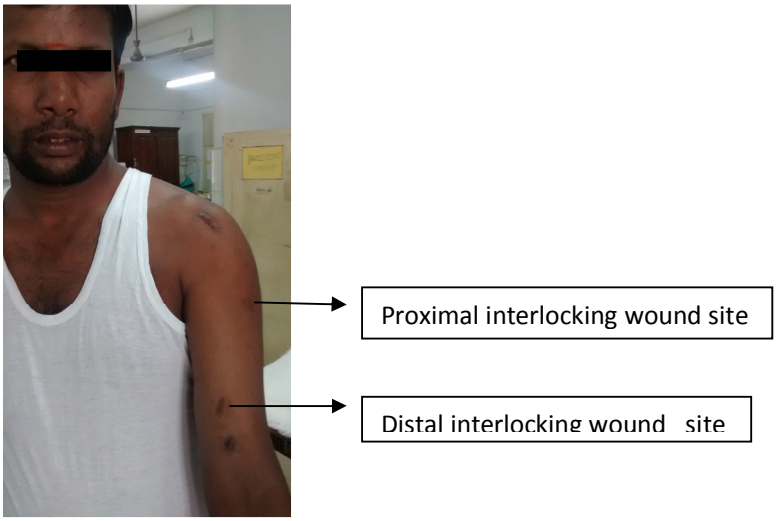


Fig. 49

Post surgical scar site

Fig. 50

Post surgical scar site

Healthy post-surgical scar showing entry , proximal and distal interlocking nail wound sites as shown in the figure above (Fig. 48,49 and 50) .

Fig. 51.Follow up X-ray at 4 weeks

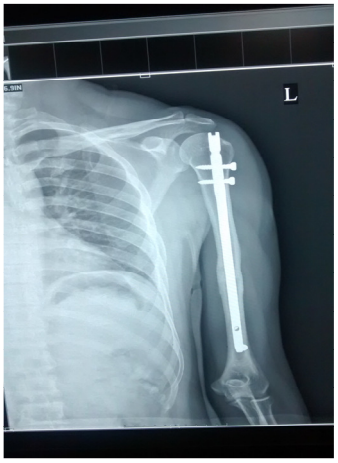


Fig. 52 .Follow up X-ray

Patient followed up at 14 weeks. Fracture site shows excellent radiological union as shown in the (fig. 51 and 52) above.

ILLUSTRATIVE CASE 3

Mr M – II , a 55 year old male (fig. 53), known hypertensive on drugs, fell from a height of about 10 feet and sustained a closed AO type 12B2 fracture of the left humerus. He was conscious and oriented and his vitals were stable. His local examination revealed swelling and abnormal mobility at left arm.

Fig. 53. Clinical photograph

X - rays of the left arm with shoulder anteroposterior and lateral views (fig. 54) were taken. He had a comminuted fracture of the middle third shaft fracture humerus. The type of the fracture was Muller type 12B2. The fracture was initially stabilised with a U- Slab (fig.53).

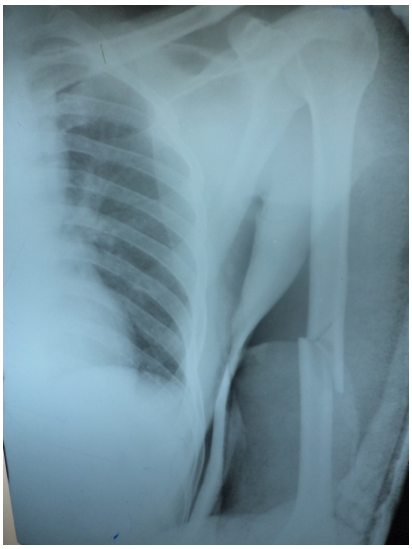


Fig. 54 Pre-operative X-ray

He was taken up for surgery on the 18th day following injury. Minimally invasive plate fixation (fig. 61) was done for this patient. The region of diaphyseal comminution was not disturbed, the major fracture fragments were reduced and length and varus -valgus alignment was corrected under C-arm and an inter-locking nail was introduced to biologically bridge the diaphyseal comminution. The nail was locked distally and proximally.

He was given post operative intravenous antibiotics and dressings . Physiotherapy in the form of gentle pendilum ecersises and shoulder and elbow mobilisation exercises were started . He was reveiwed after 3 weeks.

At 14 weeks follow up ,he had acceptable shoulder range of motion of almost 80º(fig.55,56,57,58 and 59) and X-rays showed evidence of radiological union in the form of callus formation.(fig. 62).

Fig. 55

Post-operative abduction

Fig. 56

Post-operative external rotation

Fig. 57-Post operative abduction

Fig. 58 Post operative flexion

Fig. 59 Post operative extension

Fig. 60

Post surgical scar site

Patient was followed up at 14 weeks .He had excellent range of movements in flexion , extension , abduction , external and internal rotation as seen in the (fig.55,56,57,58 and 59) above Post-surgical scar sites are seen in the (fig. 60) above.

Fig. 61

Post-op X-ray at 4 weeks

Fig. 62

Post-op X-ray at 14 weeks

The patient has excellent reduction and good union. He achieved radiological union at 14 weeks as shown in the figure above (Fig. 62). Proximal end of the interlocking nail well buried into the head.

ILLUSTRATIVE CASE 4

Mr. J, 23 year old had his two wheeler hit by a median. He was received in the emergency ward. On examination he was conscious, oriented and had no other significant injuries. His vitals were stable. His local examination revealed gross swelling and abnormal mobility of the right arm.

X- rays of the right arm with shoulder antero-posterior and lateral views (fig. 64) were taken, they revealed a fracture of the middle third distal third shaft fracture humerus. The type of the fracture was Muller type 12A3. The fracture was initially stabilised with a U-Slab (fig. 63).

Fig. 63 Clinical photograph

Fig. 64 Pre operative X- ray

He was taken up for surgery on the 7 th day . A closed reduction and internal fixation with interlocking nail was done.

Fig. 65

Post operative Internal rotation

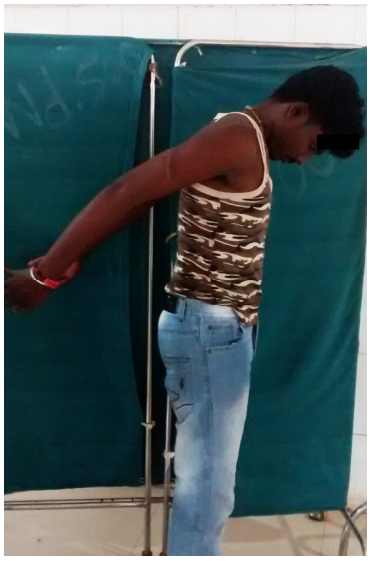


Fig. 66

Post operative extension

Fig. 67

Post operative abduction

Fig. 68

Post operative external rotation

Fig. 69

Post operative flexion

Patient followed up at 14 weeks . He showed excellent range of movements in abduction , flexion , extension , internal and external rotation as seen in (fig. 65, 66,67,68 and 69) above.

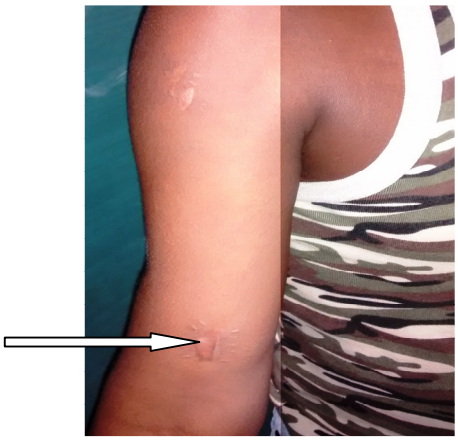


Fig. 70

Post surgical scar site.Arrow marking the distal locking site.

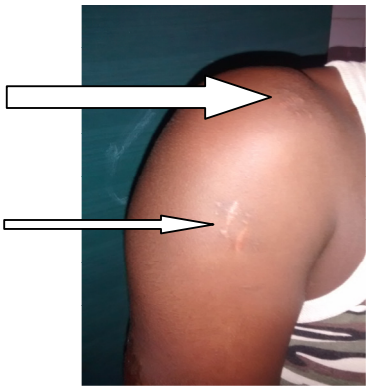


Fig. 71

Post surgical scar site. Arrow marking the entry and proximal locking site

His post surgical scar site over entry site and proximal interlocking site healthy as seen in the (fig. 70 and 71) above.

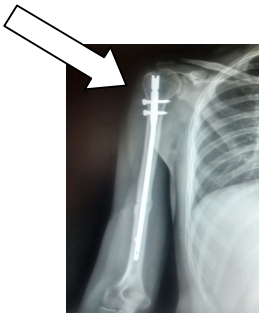


Fig. 72
8 week follow up X-rays

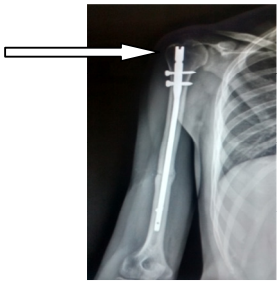


Fig. 73
10 weeks follow up X-rays

Fig. 74

12 week follow up X-rays

His follow up X-rays shows fracture united well and proximal end of the interlocking nail well buried into the head and he did not have any impingement. He had excellent radiological union of the fracture as seen (fig. 72, 73 and 74) above.

ILLUSTRATIVE CASE 5

Mr.V, 25 year old male ,met with an accident while riding a two wheeler ,came with complaints of pain and inability to move his left upper limb . On examination the patient was conscious, oriented and stable vitals . Local examination revealed swelling , tenderness , deformity , abnormal mobilty and crepitus in the left arm . There was no distal neurovascular deficit. Examination of all other systems , limbs , spine and pelvis was clinically normal

Fig. 75 Clinical photograpgh

X-rays of the left arm with shoulder antero-posterior and lateral views (fig 76.) were taken. They revealed a fracture of proximal third and middle third junction humerus. The type of the fracture was Muller type12 A2 . The fracture was initially stabilised with a U-Slab (fig. 75).

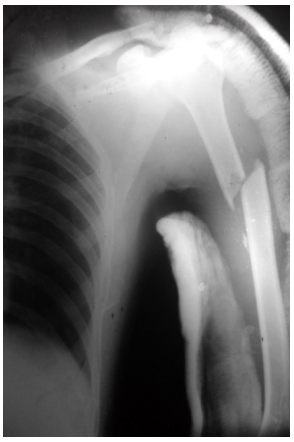


Fig. 76 Pre-operative X-ray

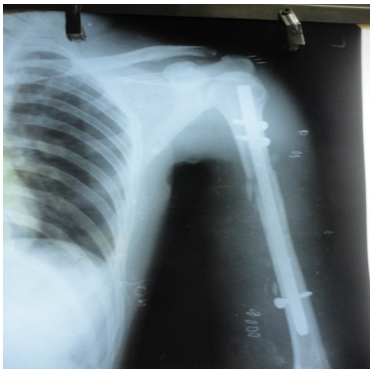


Fig.77 Post-operative X-Ray arm in slight internal rotation

He was taken for surgery and closed reduction and internal fixation done with intramedullary interlocking nail as seen (Fig.77) above. Proximal end of the nail well burried into the head. proximally two interlocking bolt and distally one interlocking bolt fixed.

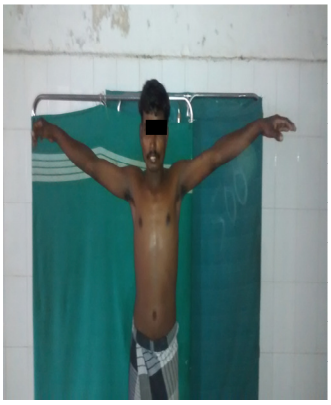


Fig.78.Post-operative-abduction

Fig.79. Post operative abduction

Fig. 80

Post operative flexion

Fig.81

Post operative extension

He was on regular follow up and he had good physiotherapy programe. He had excellent range of movement with abduction more than 130° as seen in (Fig.78 and 79) above. His flexion and extension movement were also excellent as seen in (Fig.80 and 81) above.

Fig.82

Post-operative external rotation

Fig.83

Post-operative internal rotation

His rotational movement both internal and external were also excellent as seen in the (Fig.82 and 83) above.

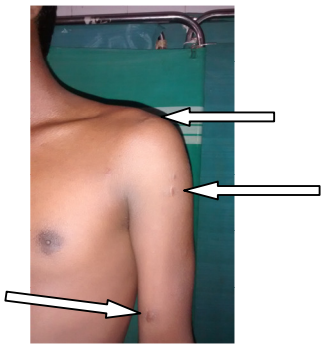


Fig.84

Post Surgical scar

His post surgical scar over the entry site , proximal and distal interlocking site was healthy as shown with arrows in the figure (Fig.84) above.

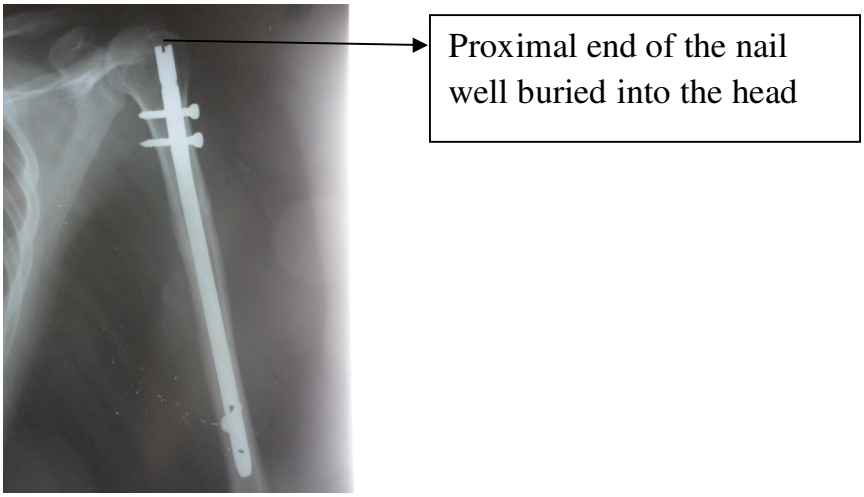


Fig.85 12 week follow up X-ray

The patient has good reduction and the fracture gets united as shown in the figure (Fig.85) above.

6. RESULTS

Of the thirty patients enrolled in the study 25 males and five females. (table- 2, figure-98) The most common age group is thirty to forty. (table- 1, figure-97)

Main cause of injury in these patients is vehicle accidents. (table- 3, figure-99) There were 21 AO type 12A, 10, 12B type and no 12C type. (table- 5, figure-101) The mean duration between injury and surgery one week. (table- 11, figure-107) All these patients had medico legal case entry and were closed injuries. In these study results of 31 fractures in 30 patients with humeral shaft fracture treated with closed reamed interlocking nail was analyzed by AMERICAN SHOULDER AND ELBOW SURGEON SCORE produced in annexure, 90.3 % acceptable outcome. Rest had fair outcome. We did not have any poor result.

Two patients in this series had associated Monteggia fracture dislocation on ipsilateral side and they were fixed with ulna plating. (table-7, figure-103) One patient had tibia fracture on ipsilateral side treated with plating. None of our patient had any infection, bleeding, implant removal and prolonged antibiotics. We did not do any augmenting procedure like bone marrow injection and bone grafting. We had 20 cases treated unreamed with 6mm diameter of nail. These 20 cases which were done without

reaming achieved union. (table- 8, figure-104) Mainly because of closed reduction and preservation of hematoma. Reamed nail had reamed with 7mm or 8mm reamer. Average interval between injury and surgery is seven days. Total time taken 12-15 weeks (table- 10, figure-106). C-arm average of 5 to 8 shots taken. Average time of surgery is fifty five minutes. None of the case needed blood transfusion.

We had fair results in three cases with complications of 1. Shoulder stiffness and 2. Nail impingement. These complications are presented below.

1. Shoulder stiffness

We had two cases of shoulder stiffness.The first patient was the one had open Monteggia fracture dislocation associated with fracture humerus. The surgery was delayed after 10 days till the forearm wound settled He has residual stiffness of shoulder glenohumeral movement 80^0

Fig.86 Follow up X-ray

Fig.87 the maximum available movement in the patient

Fig.88 the maximum available movement in the patient , with patient trying to shrug the shoulder.

Above two figures show patient having restriction in abduction at 80°

(Fig 87 and 88)

The second patient was a 36 yr old housewife from Papanasam. She did not have proper physiotherapy programme as advised and she was not in regular follow up. She had stiffness of right shoulder as seen (Fig.89 and 90) below.

Fig.89 abduction 90^0

Fig.90 abduction 90^0

Fig.91 follow up X-rays

2. Nail impingement

Mrs F, 30 year old lady a teacher (fig.92), came to us with a history of vehicle accident. On examination she was conscious and oriented and her vitals were stable.

Fig.92 Clinical photograph

Anteroposterior and lateral X-rays were taken which revealed closed AO type 12, A2 fracture of the right humerus middle 3rd. There were no associated injuries. He was placed in an U- slab as seen (Fig.92) below

She was taken up for surgery on the 6th day . A closed reduction and internal fixation with interlocking nail was done. She was given post operative intravenous antibiotics and dressings . Physiotherapy in the form of gentle pendilum excersises and shoulder and elbow mobilisation exercises were started . she was reveiwed after 3 weeks.

At 14 weeks follow up ,she had acceptable shoulder range of motion of almost 80º(fig.93 and 94) and X-rays showed evidence of radiological union in the form of callus formation.(fig.95 and 96).

Fig.93
Post operative Abduction

Fig.94
Post operative Abduction

Fig.95

Post operative internal rotation

Fig.96

Post operative external rotation

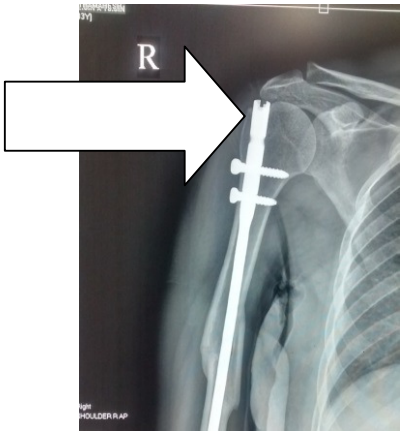


Fig.97

Follow up X-rays

X-ray of this patient shows proximal end of the nail protruding out resulting in nail impingement as seen (Fig.97) above.

Fig.98

Follow up X-ray

MASTER CHART															
S.No.	NAME	AGE	SEX	IP No	MOI	SIDE	AO TYPE	LEVEL	ASSICATION FRACTURES	DOA	DOS	NAIL LENGTH DIAMETER	TIME TO UNITE	FOLLOW UP	COMPLICATION
1	SABU	60	M	1417616	RTA	B/L RIGHT	12A3	M/3	NIL	11/6/2012	11/12/2012	7X26 mm	14 wks	52	NIL
2	SABU	60	M	1417616	RTA	LEFT	12B2	U/3	NIL	11/6/2012	11/16/2013	6x26 mm	15 wks	52	NIL
3	MANO	47	M	1422554	RTA	RIGHT	12A2	M/3	# TIBIA RT	12/19/2012	12/27/2012	6x26 mm	14 wks	52	NIL
4	VINAY	39	M	2564	RTA	RIGHT	12B3	M/3	NIL	1/19/2013	1/27/2013	7 23 MM	14 wks	50	NIL
5	NOUR	35	F	1432904	RTA	RIGHT	12B2	M/3	NIL	1/18/2013	1/28/2013	7X26 mm	13 wks	50	SS
6	RAJ	37	M	4237	RTA	RIGHT	12A3	L/3	NIL	2/15/2013	2/23/2013	6 25 MM	14 wks	48	NIL
7	MAN	55	M	1443165	ASSAULT	LEFT	12B2	M/3	NIL	3/7/2013	3/12/2013	7x25 mm	14 wks	47	NIL
8	RENGA	36	F	1442463	RTA	RIGHT	12A2	M/3	NIL	2/21/2013	3/28/2013	6x25 mm	14 wks	46	NIL
9	KASI	33	M	1442463	RTA	LEFT	12A3	M/3	NIL	3/16/2013	3/26/2013	6x25 mm	14 wks	46	NIL
10	SUR	48	M	1487634	RTA	RIGHT	12A3	M/3	NIL	3/15/2013	3/23/2013	7 x 22MM	13 wks	46	NIL
11	MARU	55	M	1432651	ASSAULT	LEFT	12A3	U/3	NIL	4/6/2013	4/16/2013	6x 22 MM	14 wks	45	NIL
12	KOKILA	49	M	5231	RTA	RIGHT	12A2	M/3	NIL	4/26/2013	5/9/2013	6 x 23 MM	14 wks	44	NIL
13	LATH	32	F	1456720	ASSAULT	LEFT	12A2	M/3	NIL	6/1/2013	6/4/2013	6x 24 mm	13 wks	42	NIMP
14	THIRU	54	M	1453401	RTA	LEFT	12A2	U/3	NIL	5/30/2013	6/6/2013	6x26 mm	12 wks	42	NIL
15	VIK	35	M	2679	RTA	LEFT	12B2	M/3	NIL	6/26/2013	7/5/2013	7x 24MM	14 wks	39	NIL
16	SUN	40	M	1880	RTA	RIGHT	12A3	U/3	NIL	8/20/2013	8/29/2013	6x 24 MM	15 wks	38	NIL
17	MUTHU	49	M	3154	RTA	LEFT	12B2	M/3	NIL	8/27/2013	9/4/2013	6x 23 MM	15 wks	36	NIL
18	KIRU	46	M	145239	RTA	RIGHT	12B2	L/3	NIL	8/28/2013	9/6/2013	6x 23 MM	15 wks	34	NIL
19	GAYU	37	F	4376	RTA	LEFT	12B2	M/3	NIL	9/26/2013	10/2/2013	6x 26 MM	15 wks	32	NIL
20	TAMIL	29	M	1479101	RTA	RIGHT	12A3	M/3	MONTEGGIA RT	10/6/2013	10/14/2013	6x23 mm	13 wks	32	NIL
21	MURUGA	21	M	1428626	RTA	RIGHT	12A2	L/3	MONTEGGIA RT	10/20/2013	10/28/2013	6x22 mm	14 wks	30	SS
22	PANEER	42	M	1271	RTA	RIGHT	12A3	M/3	NIL	11/18/2013	11/25/2013	6x23 MM	14 wks	30	NIL
23	THANG	38	M	7854	RTA	RIGHT	12A3	M/3	NIL	11/27/2013	12/6/2013	6x24 MM	13 wks	30	NIL
24	SAKTHI	43	M	1423	RTA	RIGHT	12B2	U/3	NIL	1/3/2014	1/10/2013	7x24 MM	14 wks	24	NIL
25	USHA	35	F	3608	RTA	LEFT	12A2	M/3	NIL	1/21/2014	1/30/2014	7x24 mm	13 wks	24	NIL
26	JOSE	23	M	1483132	RTA	RIGHT	12A3	M/3	NIL	3/25/2014	2/4/2014	6x25 mm	13 wks	22	NIL
27	VAITHI	25	M	6903	RTA	LEFT	12A2	U/3	NIL	2/6/2014	2/12/2014	8x22 mm	15 wks	22	NIL
28	SABRI	41	M	3245	ASSAULT	LEFT	12A2	M/3	NIL	2/16/2014	2/25/2014	6x 25 MM	14 wks	22	NIL
29	MAN	45	M	8399	RTA	LEFT	12A3	M/3	NIL	2/18/2014	3/6/2014	7x23 mm	14 wks	20	NIL
30	ADAI	46	M	17532	RTA	LEFT	12A3	M/3	NIL	3/22/2014	4/2/2014	7x22 mm	14 wks	20	NIL
31	VAS	61	M	14178	RTA	LEFT	12B2	U/3	NIL	3/28/2014	4/6/2014	6x26 mm	15 wks	52	NIL

Table 1: Age Distribution

Age in years	Frequency	Percentage
21-30	4	13.3
31-40	11	36.7
41-50	10	33.3
51-60	4	13.3
>61	2	3.3
Total	30	100.0

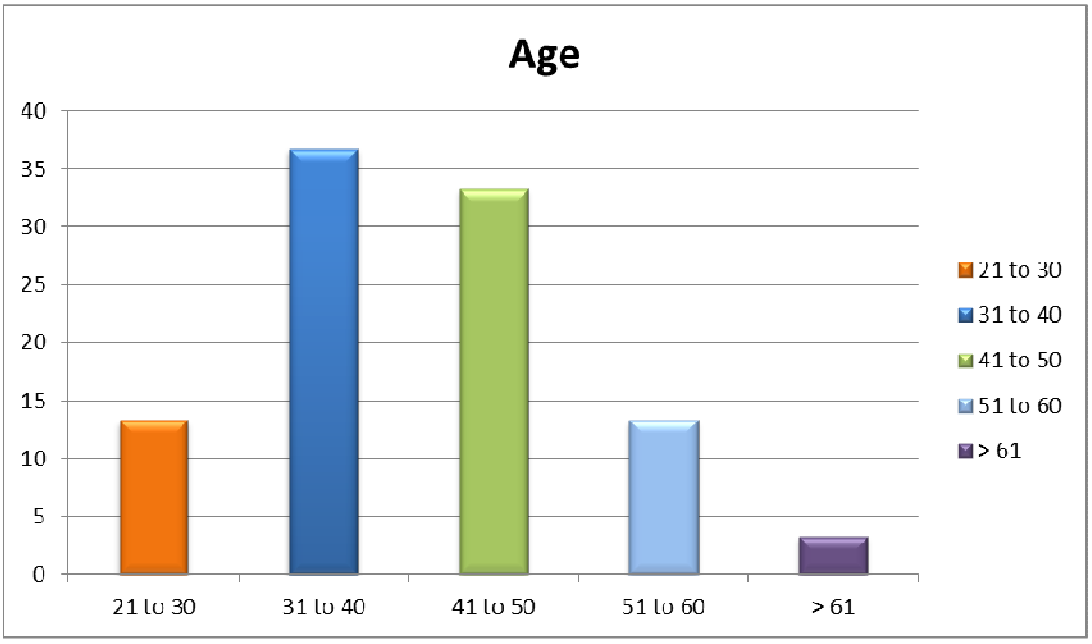


Fig . 97 Bar diagram showing age distribution

Table 2 : Sex Distribution

Sex	Frequency	Percentage
M	25	83.3
F	5	16.7
Total	30	100.0

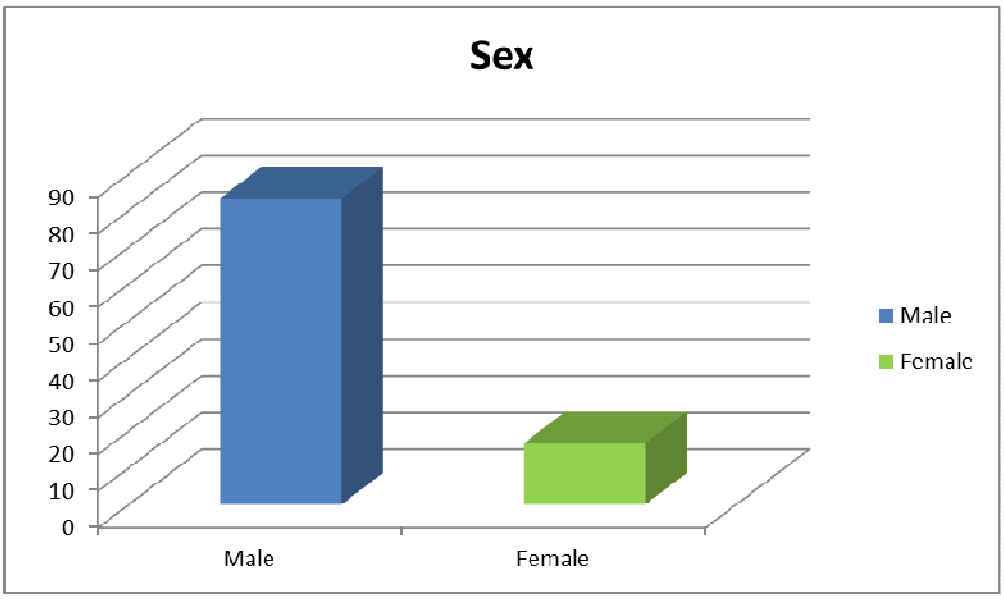


Fig. 98 Bar diagram showing sex distribution

Table 3 : Mode of Injury

Mode of Injury	Frequency	Percentage
RTA	26	86.7
ASSAULT	4	13.3
Total	30	100.0

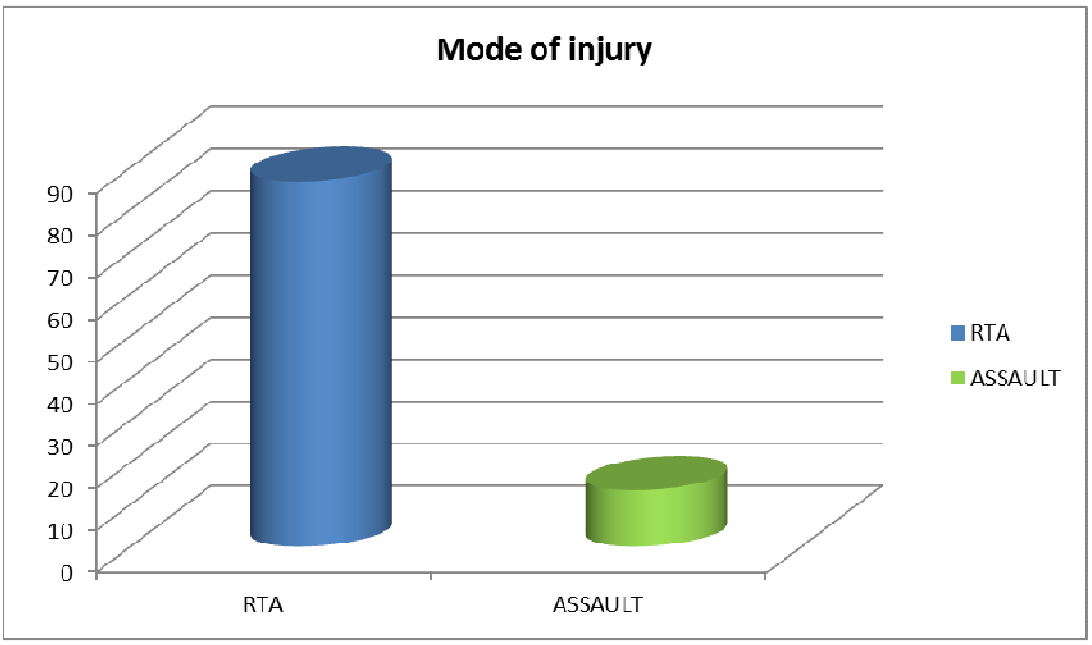


Fig 99. Bar diagram showing mode of injury

Table 4 : Side

Side	Frequency	Percentage
Right	15	50.0
Left	14	46.7
Bilateral	1(2)	3.3
Total	30	100.0

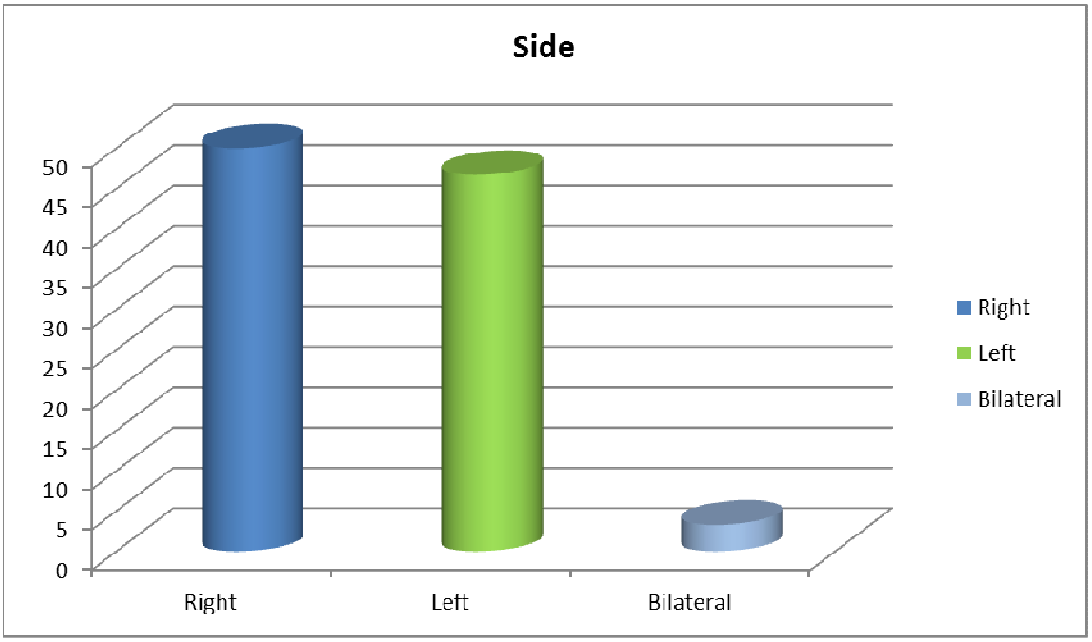


Fig.100 Bar diagram showing side

Table 5 : AO Type

AO Type	Frequency	Percentage
12A2	9	30.0
12A3	12	40.0
12B2	8	26.7
12B3	1	3.3
Total	30	100.0

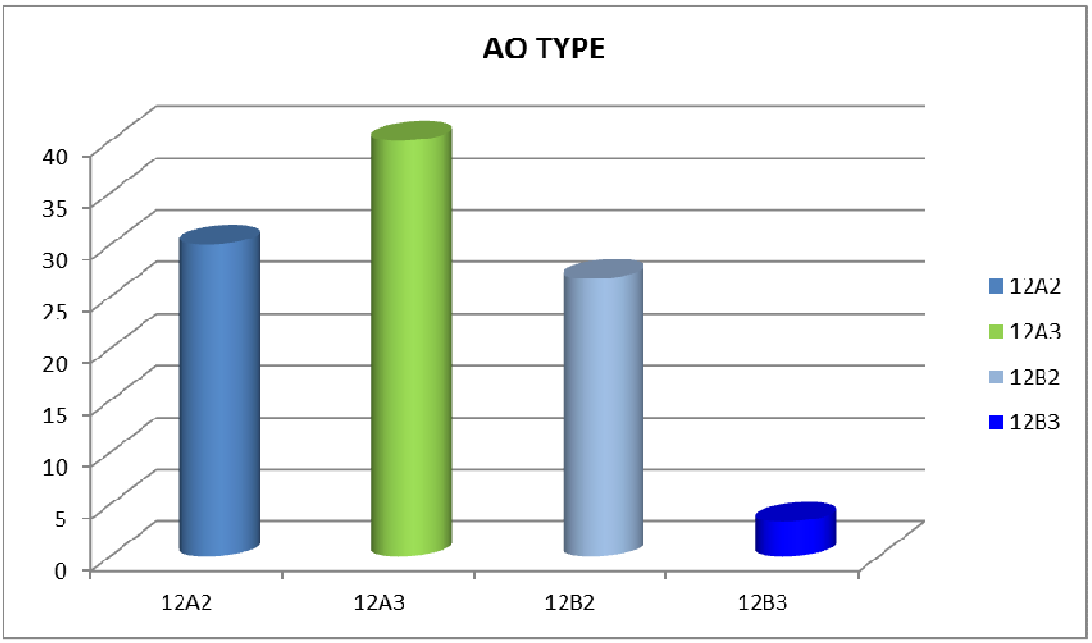


Fig.101. Bar diagram showing AO type fracture

Table 6 : Level of Injury

Level of Injury	Frequency	Percentage
Upper 3rd middle 3rd junction	6	20.0
Middle 3rd	21	70.0
Middle 3rd Lower 3rd junction	3	10.0
Total	30	100.0

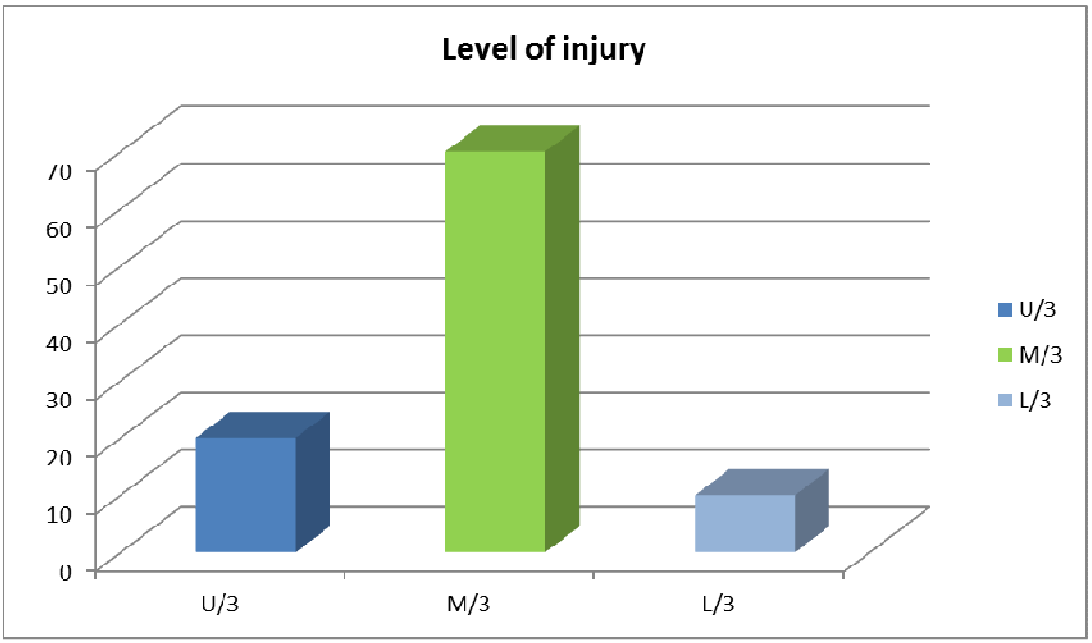


Fig. 102. Bar diagram showing level of injury

Table 7 : Associated Fractures

Associated Fractures	Frequency	Percentage
Monteggia right side	2	6.6
# Tibia right side	1	3.3
Nil	27	90.0
Total	30	100.0

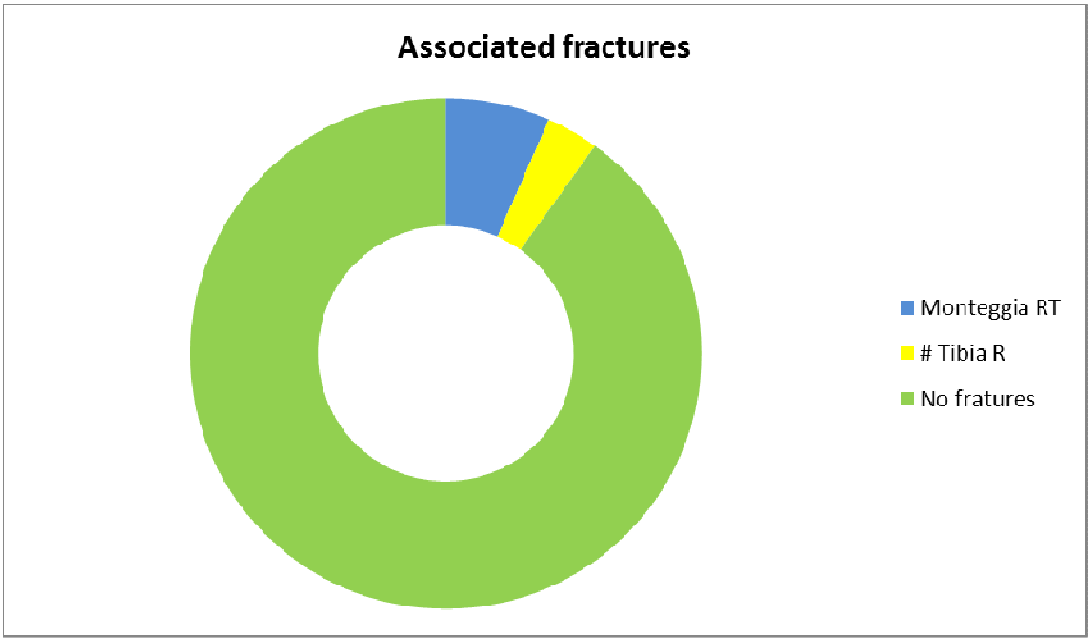


Fig. 103. Associated Fractures

Table 8 : Nail diameter

Nail diameter	Frequency	Percentage
6	19	63.3
7	10	33.3
8	1	3.3
Total	30	100.0

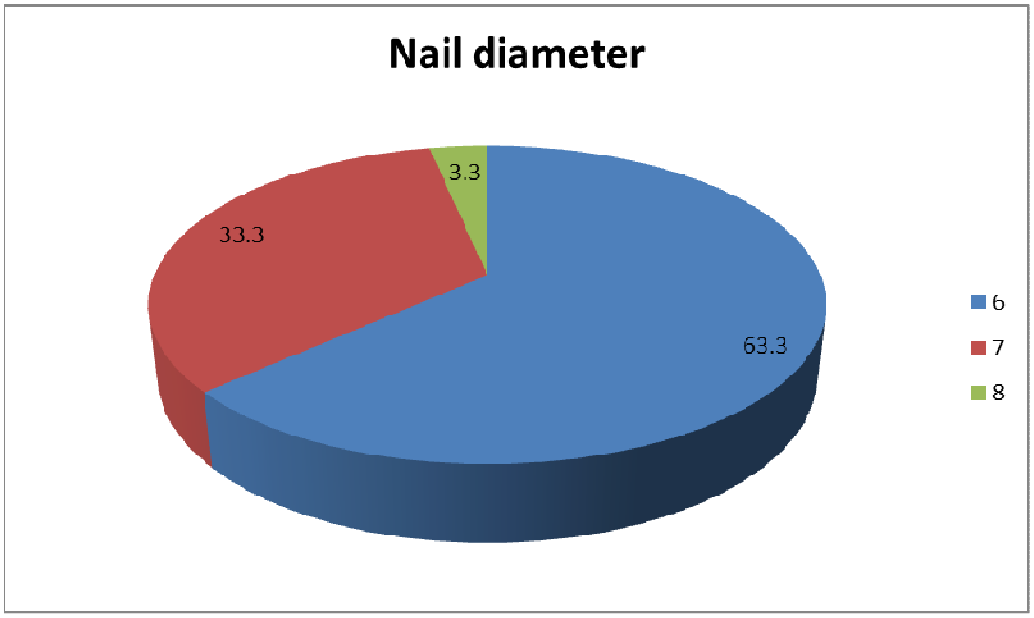


Fig. 104 Pie chart showing nail diameter

Table 9 : Nail length

Nail length	Frequency	Percentage
22	5	16.7
23	7	23.3
24	6	20.0
25	6	20.0
26	6	20.0
Total	30	100.0

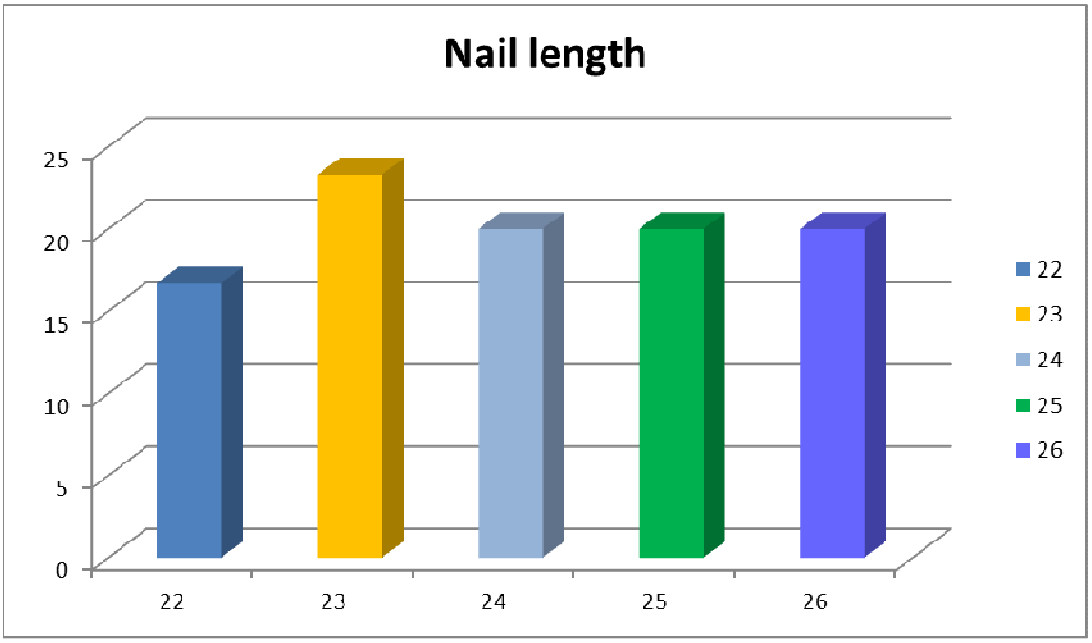


Fig. 105 Bar diagram showing nail length

Table 10 : Time to Unite

Time to Unite	Frequency	Percentage
12	1	3.3
13	7	23.3
14	16	53.3
15	6	20.0
Total	30	100.0

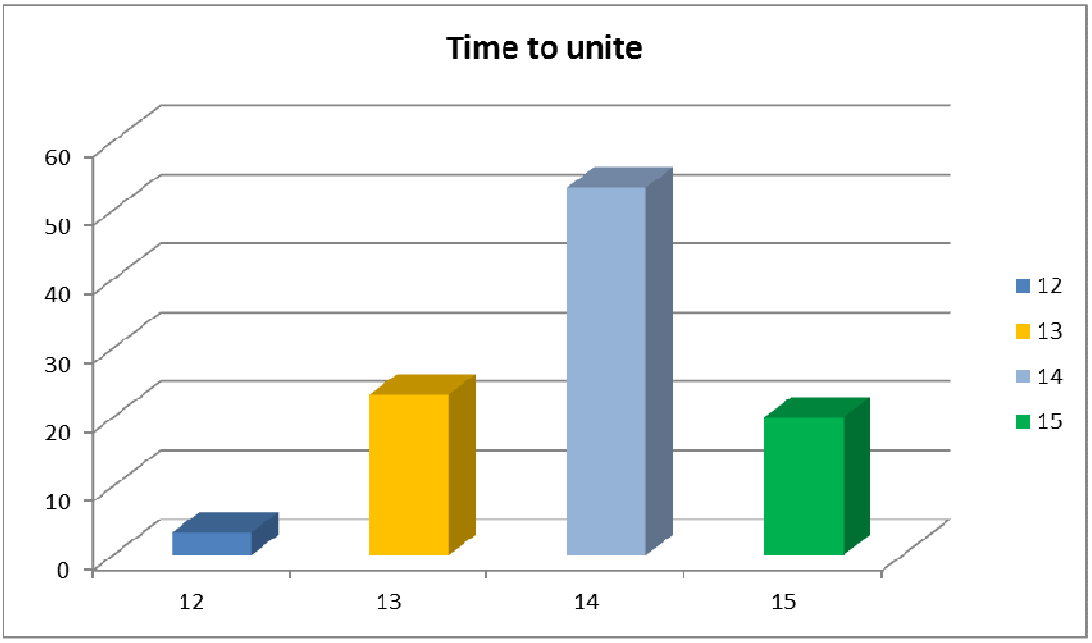


Fig.106. Bar diagram showing time to unite

Table 11 : Time interval

Time interval	NUMBER	PERCENTAGE
1 to 5	3	9.67%
6 to 10	28	90.32%
11 to 15	0	0%

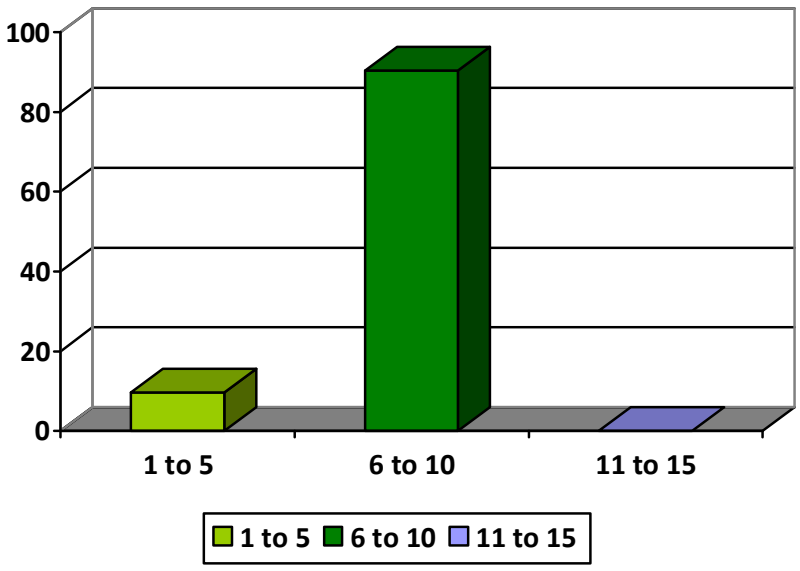


Fig.107. Bar diagram showing time interval

Table 12 : Functional outcome by American Shoulder elbow surgeon scoring system

GRADING	NUMBER	PERCENTAGE
EXCELLENT	18	58.06%
GOOD	10	32.25
FAIR	3	9.6%
FAILURE/POOR	0	0

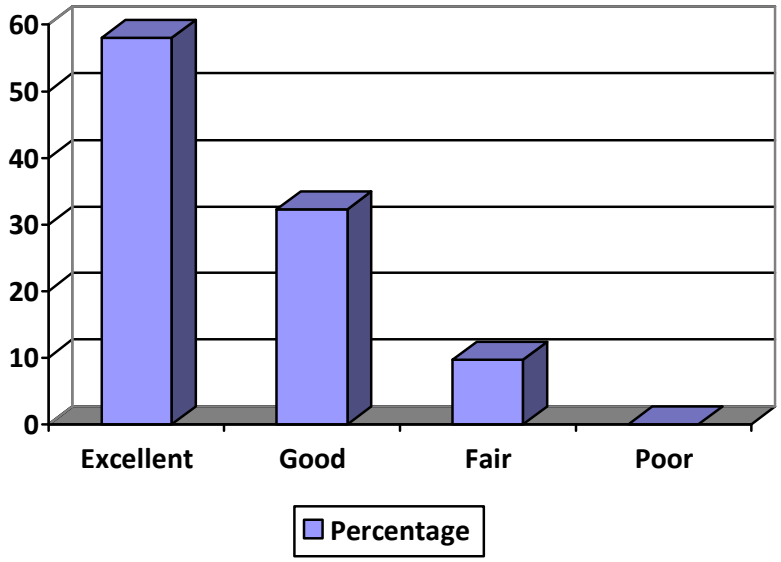


Fig.108. Bar diagram showing Functional outcome

7.DISCUSSION

By just lifting the arm against gravity, the humerus is subjected to a load of about 70% body weight. While bending loads on the fracture can be resisted by the nail, the torque in need to construct by nail bone constructs. In humeral interlocking nail where closed reduction is done radial nerve not exposed. This is advantage over plating. As already elaborated 3cm proximal to olecranon and 2cm distal to surgical neck is the area in humerus where fracture could be treated by intramedullary interlocking nail. Indication for the non-union and pathologic fracture intramedullary interlocking nail is preferred for humeral fracture stabilization due to limited exposure and adequate secure fixation. Their merits judged against the problem of antegrade insertion which is routinely used. But the shoulder stiffness and abduction problem do occur even in conservative treatment and plating .Retrograde nailing is technically tough and can end up with supracondylar fracture. Dynamic compression in plating for those fracture need good exposure of the fracture. The standard non locked nail which was used originally used is now out of use. Interlocking nail is the current implant where nail is considered. [61]

Putting locking bolt both in proximal and distal end fix with major fragment and prevent relative movement of the fragment along nail. This is called as static locking. Here length and rotation of fragments are controlled. Static

locking achieves a fixation in presence of severe comminuted fracture where opening fracture will be a disaster in the form of devascularisation and infection. In bridging fracture, only proximal and distal fragment are fixed. It may appear as though major fragment are not in contact, but closed method of fixation gives good environment for fracture healing so that tissues are viable and fracture proceeds to union. Static locking used in difficult fracture like segmental fracture, comminuted fracture , fracture with bone loss and pseudoarthrosis. [61] The site of maximum number of fractures was the middle third and the common AO type was 12-A3 with twenty cases- almost two third of all cases. There was equal involvement of both the side humerii. This was possibly decided by the side of impact and not the handedness of the patient. There was male preponderance in the study and most patients were in the age group of 31 to 50 years. The implant we used interlocking nail of Sharma Surgicals Equipments Private Limited ®. The most frequent size nail we used was 6mm. This was an un-reamed nail. As it was deliberated in literature review there are works discouraging the reaming of the humerus in interlocking nailing.[35,38 ,53] The next common diameter was 7 mm. Preserving the biological hematoma at the fracture site is the most important aspect in closed treatment of fractures. Passing the rigid implant into the medullary canal, achieves correction of deformity. These two factors are possible reasons of our acceptable results.

The length of the nail is 23 in seven cases. The average nail length is 24cm. The main problem in the entire interlocking nail is the distal-hole fixation. It is the slippery anterior surface that was creating difficulty in the distal locking of the nail. The common perception is difficulty in reduction was not encountered in this series. We were able to get good alignment in traction is supination of forearm and wide reaming of the proximal fragment.

The other issue is the contact of proximal and distal fragments. In case of comminution the length of the nails chosen so that the length of the humerus is maintained. In these cases the reverse jamming is not done. In such cases closed reduction is of great importance. This is because if any attempt is done to open such fragments, then the fragments will devoid of soft tissue. The one problem which is expected is the removal of implant. But none of our patients have requested for the removal of the nail. This is a much deliberations as the closed method of treatment may not be possible if patient has another fracture with nail in situ hypothetically.

The widely published problem of rotator cuff injury was not seen in most of the patients. However is only one patient has reduced abduction This patient was not coming for regular follow up . Maximum patients united in 14 weeks and the average time to unite in these cases is time to unite was 13.5 weeks.

8. CONCLUSION

The study on 31 consecutive closed humeral shaft fractures concludes that closed humerus shaft fractures taken early and fixed with antegrade nailing after closed reduction under image intensifier control, in a less invasive technique, achieve acceptable results clinically and radiologically. The selection of nail entry from anterior proper positioning of upper end of the nail below the level of the head of humerus giving good range of abduction

American Shoulder Elbow Surgeon ASES

	Normal 4	Mild compromise 3	Difficulty 2	With aid 1	Unable 0	NA - -
Reach Back pocket						
Perineal care						
Wash opposite axilla						
Eat with utensil						
Comb hair						
Use arm at shoulder level						
Carry 10lb at side						
Dress						
Sleep on affected side						
Use hand overhead						
Pull						
Lift						
Throw						

LIST OF ABBREVIATIONS USED

AO	.....	Arbeitsgemeinschaft fur Osteosynthesefragen
ASIF	.....	Association for the Study of Internal Fixation
Wks	.....	Weeks
Ex	.....	Extension
F	.....	Female
H/O	.....	History of
I.P.	.....	Inpatient
L/3	.....	Lower third
M	.....	Male
M/3	.....	Middle third
No.	.....	Number
RTA	.....	Road traffic accident
SS	.....	Shoulder stiffness
NIMP	.....	Nail impingement
U/3	.....	Upper third
Yrs	.....	Years
#	.....	Fracture
RT	….	Right
LT	….	Left
HIV	….	Human immuno deficiency Virus
HBsAg	….	Hepatitis – B surface antigen
ECG	….	ELECTROCARDIOGRAM
DOA	….	Date of Admission
DOS	…	Date of Surgery
MOI	…	Mode of injury

PROFORMA

Name	:	
Age	:	I.P.NO:
Sex	:	D.O.A:
Occupation	:	D.O.S:
Address	:	D.O.D.:

1. CHIEF COMPLAINTS:

- Pain
- Swelling
- Disability
- Wound
- Deformity

2. HISTORY OF PRESENTING ILLNESS:

- Time since injury
- Nature of injury : RTA/Fall/Industrial accident/Assualt
- Associated injury

3. PAST HISTORY :

- H/O chronic illness
- H/O previous injury

4. FAMILY HISTORY :

5. GENERAL PHYSICAL EXAMINATION:

Built : Nourishment :

pallor/Icterus/clubbing/cyanosis/lymphadenopathy.

Vitals : Pulse, Blood pressure, Respiratory rate, Temp.

6. SYSTEMIC EXAMINATION :

CVS	RS
P/A	CNS

7. LOCAL EXAMINATION:

Inspection:

a) Attitude

b) Swelling

c) Loss of function

d) Bruises/Laceration

e) Associated soft tissue injury

f) Deformity

Palpation:

a) Tenderness

b) Abnormal mobility

c) Crepitus

d) Shortening

a. MEASUREMENT

Length of the arm Right Left

b. MOVEMENTS

a) Shoulder

b) Elbow

c. NEUROLOGICAL STATUS:

d. VASCULAR STATUS:

e. INVESTIGATIONS:

CBC, Urine routine, Blood Sugar, Blood urea, Sr Creatinine, HIV, HBSAg., ECG , X-rays involved arm with elbow and shoulder joint Antero posterior lateral view

f. RADIOLOGICAL FINDINGS :

Type of fracture/Associated findings/Associated injuries.

MANAGEMENT:

Preliminary treatment on admission

POP 'U' Slab

Drugs : Analgesics/Antibiotics

OPERATIVE TREATMENT :

Date of surgery :

Procedure :

Immobilization after surgery :

Drugs : Analgesics/Antibiotics

Neurological status :

Check X-ray :

Physiotheraphy : ROM Excercises for Shoulder and Elbow.

Suture removal

FOLLOW UP :

	4 weeks	8 weeks	12 weeks	6 months
Complaints (if any)				
Clinical findings				
ROM Shoulder				
ROM Elbow				
Check X-ray				
Advise (Physiotheraphy)				

COMPLICATIONS:

ASSESSMENT OF FUNCTIONAL OUTCOME BY AMERICAN SHOULDER ELBOW SURGEON SCORE

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